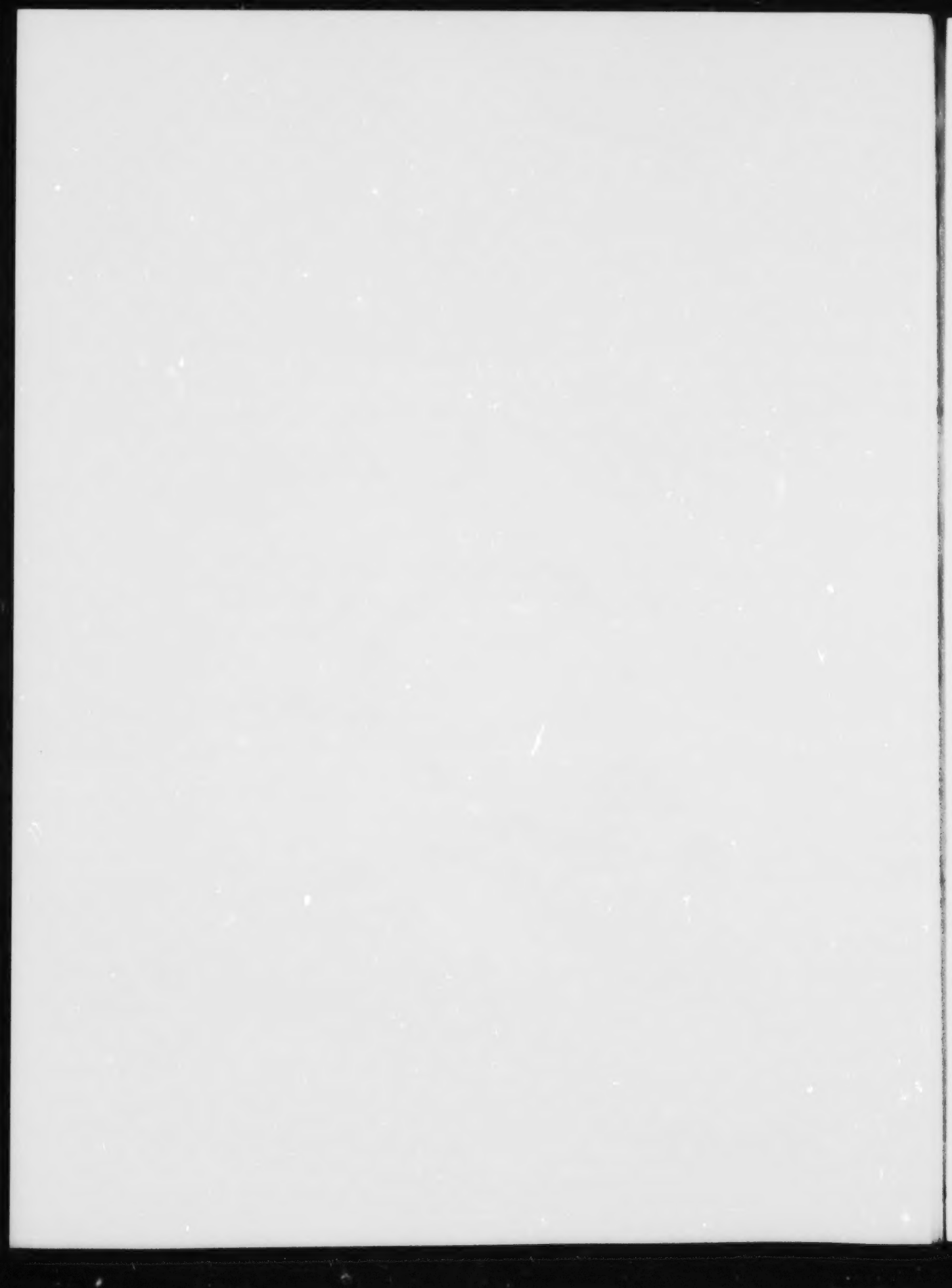


Principles and Practices of New Forestry

Land Management
Report NUMBER 71

ISSN 0702-9861

FEBRUARY 1991



Principles and Practices of *New Forestry*

A guide for British Columbians



Report Commissioned by the
Old-Growth Strategy Project

BC

76

C

L26

179

C

Principles and Practices of New Forestry

A Guide for British Columbians

by
Doug Hopwood
Lasqueti Island

Report Commissioned by the
Old-Growth Strategy
Working Group

February 1991



Canadian Cataloguing in Publication Data

Hopwood, Doug

Principles and practices of new forestry

(Land management report, ISSN 0702-9861 ; no. 71)

"Report commissioned by the Old-Growth Strategy
Working Group."

Includes bibliographical references: p.
ISBN 0-7726-1279-X

1. Forest management - Northwest, Pacific. 2.
Forest ecology - Northwest, Pacific. I. British
Columbia. Ministry of Forests. II. British Columbia.
Old-Growth Strategy Working Group. III. Title.
IV. Series.

SD146.B7H66 1991 634.9'2'09711 C91-092086-9

© 1991 Province of British Columbia
Published by the
Research Branch
Ministry of Forests
31 Bastion Square
Victoria, B.C. V8W 3E7

Copies of this and other Ministry of Forests titles are
available from Crown Publications Inc., 546 Yates
Street, Victoria, B.C. V8W 1K8.

SUMMARY

The term "New Forestry" denotes an approach to forestry developed over the past decade in the U.S. Pacific Northwest, west of the Cascades, in response to a broadening of forest management objectives and an improved knowledge of forest ecosystems.

New Forestry has not been formally defined, but is summarized by Lertzman (1990) as *"an attempt to define forest management with timber production as a by-product of its primary function: sustaining biological diversity and maintaining long-term ecosystem health."*

The social background to New Forestry includes an increased public concern with environmental issues such as loss of biodiversity in managed forests. At the same time, economic pressure to harvest old-growth timber has remained strong. These conflicting forces have led forest managers to seek better methods of integrating biodiversity and ecological concerns with timber management.

The scientific background includes an increased understanding of:

- structure/function/composition relationships in old-growth forests, and the importance of specific structural features such as large trees, standing dead trees (snags), large down logs, and the heterogeneous canopy structure;
- the extent to which such structures tend to persist through natural disturbance events such as wildfire or windstorms, providing "biological legacies" for the subsequent stand;
- the habitat value of early and late seral stages of forest, which are reduced or eliminated through intensive management; and
- the importance of large-scale and long-term effects of forest management. Other research has focused on long-term site productivity and ecological resilience.

Practices that have been proposed or adopted at the stand level include:

1. logging methods to retain standing green trees, snags, and down logs;
2. establishment of mixed species stands;
3. stand treatments to encourage development of large, widely spaced trees; and
4. other practices to enhance the diversity of managed stands or promote development of old-growth characteristics.

Practices at the landscape level have focused on minimizing forest fragmentation, providing habitat reserves and dispersal corridors within the industrial forest landscape, and integrating the long-term and large-scale effects of timber operations with ecological concerns.

In an evaluation of the applicability of New Forestry practices to British Columbia, the most important issue that predominates is that of forest management goals. New Forestry is based on the premise that conventional forestry practices sacrifice many of the ecological elements of the forest, and it seeks to conserve them by developing alternative practices. We cannot judge how applicable those practices are to the province until we decide how highly we value those ecological elements.

The ecological applicability of New Forestry varies. Some practices may only be suitable to a restricted portion of British Columbia forests, while others could be applied widely. However, forest management prescriptions must be specific to regional, site, and stand conditions.

Although most New Forestry practices represent hypotheses rather than established procedures, they are based generally on sound scientific research. It is customary and acceptable for foresters to apply new management practices on such a basis.

Recommendations for British Columbia include:

1. Development of an on-going process for public involvement in the formulation of forest management goals.
2. Development of a research program to investigate forest ecosystem function, natural disturbance and recovery regimes, and silvicultural methods for ecosystem management.
3. Increased United States/Canada co-operation in forest research.
4. Enhanced ecology content in forestry education.
5. More use of an adaptive management approach in forestry.
6. More use of a landscape/watershed perspective in forest planning.
7. Continued co-operative work on wildlife tree and snag management.
8. Establishment of ecological and wildlife habitat reserves as needed.

ACKNOWLEDGEMENTS

This report was assembled with the generous help of foresters, researchers, public servants, forest industry employees, and others from both the United States and Canada. They are simply too numerous to acknowledge individually, but I wish to express my sincere thanks to all of them.

Special thanks are due to Ken Lertzman, for his enthusiastic help with the subject material, and to Andy MacKinnon, for his patient and good natured help with the details of writing and publication.

I am also grateful for the permission to reproduce the following material.

Figures 2, 5, and 8 are from *The Fragmented Forest* by Larry D. Harris, copyright 1984 by University of Chicago Press. Reprinted by permission.

Figure 3 is reproduced courtesy of the USDA Forest Service Pacific Northwest Research Station, and the authors, J.F. Franklin and R.H. Waring.

Figure 4 is courtesy of the USDA Forest Service Pacific Northwest Research Station.

Figure 7 is courtesy of Blue River Ranger District, Willamette National Forest.

Figure 9 is from *Maintaining the Long-term Productivity of Pacific Northwest Forest Ecosystems* by Perry *et al.*, copyright 1989 by Timber, Inc. Reprinted by permission.

Figures 6 and 14 photos are courtesy of Dr. Ken Lertzman, Simon Fraser University, Natural Resources Management Program. Other photos by author.

Figure 15 is courtesy of Dr. Mark Harmon, Oregon State University, and Dr. Phil Sollins.

Figure 11 illustration is by Jane MacKay, Lasqueti Island.

Appendix 1 is reproduced courtesy of the USDA Forest Service Pacific Northwest Research Station.

Appendix 2 is reprinted courtesy of Gold Beach Ranger District, Siskiyou National Forest.

Appendix 3 is reprinted courtesy of Lowell Ranger District, Willamette National Forest.

Appendix 4 is reprinted courtesy of Willamette National Forest.

Appendix 5 is reprinted courtesy of the author, Dr. William A. Atkinson, Department of Forest Engineering, Oregon State University.

TABLE OF CONTENTS

SUMMARY	iii
ACKNOWLEDGEMENTS	v
I INTRODUCTION	1
Objectives and Approach of This Report	1
II BACKGROUND	1
General Background	1
Economic Background	2
Social Background	2
Scientific Background	3
New Forestry and New Perspectives	13
III NEW FORESTRY PRACTICES	13
Practices and Prescriptions	13
Spatial Scale	13
Stand Level Practices	14
Landscape Level Practices	20
New Forestry Practices in Other Regions and Ownerships	23
IV APPLICABILITY OF NEW FORESTRY PRACTICES TO BRITISH COLUMBIA	24
Comparison of Goals and Resources	25
Scientific Basis of New Forestry Practices	31
Scientific Evidence and Management Practice	35
V DISCUSSION	36
Comments Received	36
New Forestry: What it Can and Can't Do	36
Other Analyses of New Forestry	36
VI RECOMMENDATIONS	37
Defining Goals	37
Research	37
International Co-operation	38
Education	39
Adaptive Management	39
Watershed Inventory and Planning	40
Wildlife Trees and Snags	40
Habitat Reserve Areas	40
Ecological Reserves	40
VII REFERENCES	41

VIII APPENDICES

1. Summary of Distinctive Characteristics of Westside Old-growth Douglas-fir Forests	46
2. Silvicultural Systems Used in New Forestry on the Westside	48
3. Process for Evaluating Significance of Old-Growth Stands	70
4. Standards and Guidelines for Management of Riparian Area	76
5. Another View of New Forestry	84

LIST OF FIGURES

1. Industrial tree farm, Washington State. Much of the private forest land of the Westside is managed intensively for timber production. Young age classes predominate	3
2. Annual timber cut from the Willamette National Forest, in million board feet	4
3. Ecological and habitat functions of four major structural components of old-growth Douglas-fir forests	5
4. Successional stages of decomposition in logs and snags	6
5. Ordination of western Oregon mammals along a successional gradient	7
6. Ecosystem recovery following wildfire, Mount Ranier, Washington. "Biological legacies," such as snags and down logs, play a role in recovery from natural disturbances	8
7. Infra-red air photo mosaic showing dispersed patch clearcutting, Blue River Ranger District, Willamette National Forest, Oregon	10
8. Size class distribution of the 319 remaining old-growth stands in the Siuslaw National Forest	11
9. The Blue River Ranger District Residue Guideline	15
10. Recently logged setting, Blue River Ranger District, Willamette National Forest, Oregon. Various sizes and species of snags and green trees have been left standing. Some large down logs are left on the site; some slash was yarded or hand-piled for burning. This site was later planted with a mixture of conifer species	17
11. Temporal development of forest stands	19
12. Typical industrial forest landscape in western Oregon. Old-growth stands have mostly been eliminated. Except for some deciduous species in young regenerating stands (middle right), a near monoculture of Douglas-fir prevails	25
13. Old-growth western hemlock/Douglas-fir/western redcedar forest, Nimpkish Valley, Vancouver Island. Some old-growth forests in British Columbia are structurally very similar to those of Oregon and Washington for which New Forestry practices were designed	28
14. Progressive clearcutting, Harrison Valley, British Columbia	30
15. Predicted effect of coarse woody debris removal on yield from a western hemlock plantation in western Oregon. Rotations are (A) 30 years and (B) 90 years. Based on FORCYTE-10 model	33
16. Seed tree harvest with western larch overstory, Arrow District, British Columbia	39

I INTRODUCTION

The term "New Forestry" denotes an approach to forestry developed over the past decade in the Pacific Northwest region of the United States, in response to a broadening of forest management objectives, and based on improved knowledge of the workings of forest ecosystems. Essentially, New Forestry seeks to conserve more of the ecological values of the forest than conventional forestry practice, while permitting timber extraction. As such, it represents an affirmation of the principles of multiple use and integrated resource management.

New Forestry grew out of comprehensive ecosystem-level studies of the Douglas-fir forests west of the Cascades in Washington and Oregon, but it is now being examined throughout the Pacific Northwest. In New Forestry, the ecological processes of the natural old-growth forest are studied to provide a guiding model in the design of the managed forest. Two important levels of spatial scale are recognized: the individual stand and the larger landscape.

Although New Forestry has not been formally defined, Lertzman (1990) summarizes it as *"an attempt to define forest management with timber production as a by-product of its primary function: sustaining biological diversity and maintaining long-term ecosystem health."*

The name "New Forestry" is perhaps unfortunate, since some of its concepts were previously developed in Europe and elsewhere (G. Krumlik, B.C. Ministry of Forests, personal communication). However, the name has stuck, and it is useful in that it implies a significant change in direction from the conventional practices that have prevailed in the Pacific Northwest.

Objectives and Approach of This Report

This report:

1. briefly covers the scientific and social background of New Forestry;
2. describes some of the more significant management practices in place or planned in Washington and Oregon;
3. broadly evaluates the extent to which these practices might be applicable in British Columbia; and
4. makes recommendations.

An effort is made to examine the strength of the scientific evidence behind New Forestry practices, and to look at some of the criticisms of New Forestry that have been stated.

The objective of this report is to provide a broad overview of New Forestry. To do this, I have tapped as wide a range of information sources as possible, conducting numerous telephone interviews with people from Alaska, British Columbia, Washington, and Oregon, and making a 1-week field trip to Washington and Oregon. Also, I have reviewed published articles in the scientific and popular press, as well as documents such as management plans, environmental impact statements, research proposals, and various in-house documents.

II BACKGROUND

In forestry, management practices are usually designed and adopted in response to particular combinations of resource conditions and management objectives. To understand New Forestry, one needs some knowledge of the conditions affecting forestry activities in the Pacific Northwest in recent years. Some of these conditions are specific to the region, while others are more general.

General Background

The period since World War II has been one of unprecedented industrial expansion and population growth world-wide. There is a growing global awareness that human activities pose a serious threat to the long-term stability of many ecosystems, and that the future economic security of human society depends on

rotation, from harvest to culmination age of the regenerated stand. In contrast, some recent research has been concerned with larger units of the landscape than the single stand, and with time periods extending into several centuries to study the long-term dynamics of old-growth forests.

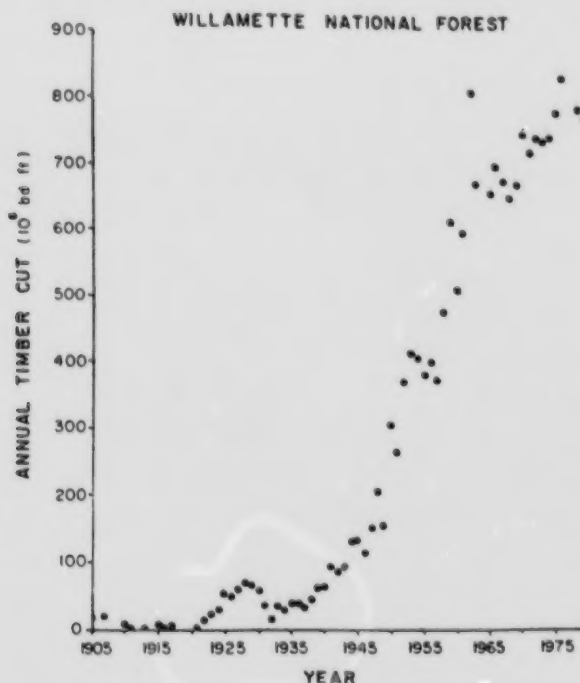


FIGURE 2. Annual timber cut from the Willamette National Forest, in million board feet. Source: Harris 1984.

Old-Growth characteristics

One centre of old-growth research has been the H.J. Andrews Research Forest, located in the Blue River Ranger District of the Willamette National Forest in central Oregon. Researchers working on the Andrews forest and elsewhere have identified some important ecological characteristics of Westside old-growth Douglas-fir forests which distinguish these systems from managed and younger stands (Franklin *et al.* 1981). They concluded that old-growth stands have a more heterogeneous structure, with more variation in tree size and greater patchiness of the understory. A summary of the distinctive characteristics of Westside Douglas-fir old-growth is included in Appendix 1.

Four major structural components which are believed to play important roles in determining the composition and function of these old-growth forest ecosystems are discussed below (Figure 3).

LARGE LIVE TREES

Depending on site factors, old-growth Douglas-fir trees commonly reach diameters of 1–2 m and heights of 50–90 m. These trees typically have deep, irregular crowns with massive branches which may accumulate several centimetres' depth of organic matter on them. Such trees frequently have broken tops. Other tree species that can develop similar characteristics with age include Sitka spruce, western redcedar, and yellow cedar. Hemlocks and true firs do not develop these properties to the same degree. These large trees influence the composition of the forest by providing habitat for epiphytic mosses and lichens, small mammals, birds, and various invertebrates.

Important functions of these trees include intercepting rain, snow, and fog, serving as a sink and reservoir for carbon, and providing a site for nitrogen-fixation, primarily by the foliose arboreal lichen, *Lobelia oregana*.

Compositional role	Structural element	Function role
◆ Distinctive epiphytes ◆ Distinctive vertebrates ◆ Distinctive invertebrates	Individual, large old-growth tree	◆ Site of N-fixation ◆ Ionic storage ◆ Interception of H_2O nutrients, light
◆ Utilized by cavity dwellers and other vertebrates	Large standing dead	◆ Energy and nutrient source
◆ Distinctive animal communities ◆ Seedbed or nursery for seedlings	Large down dead on land	◆ Site of N-fixation ◆ Energy and nutrient source
◆ Distinctive animal communities ◆ Creates habitat diversity	Large down dead in streams	◆ Site of N-fixation ◆ Energy and nutrient source ◆ Maintains physical stability of stream ◆ Retains high-quality energy materials for processing

FIGURE 3. Ecological and habitat functions of four major structural components of old-growth Douglas-fir forests. Source: Franklin and Waring 1980.

SNAGS

Although standing dead trees play some role in nutrient cycling, their most obvious effect is to increase faunal diversity by providing habitat for bats and numerous species of cavity-nesting birds. Old-growth Douglas-fir snags ordinarily remain standing for 50–75 years, while western redcedar snags may stand for 75–125 years. Snag classifications have been developed, which recognize the stages of decay through which Douglas-fir snags ordinarily progress (Figure 4). These stages are associated with changing wildlife habitat values.

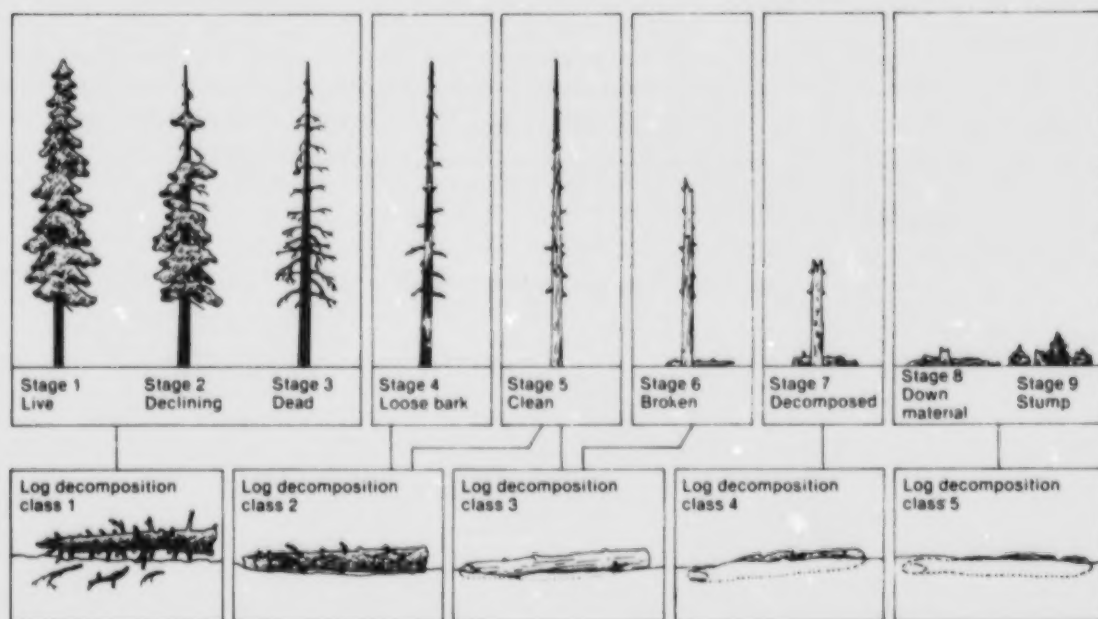


FIGURE 4. Successional stages of decomposition in logs and snags. Source: Bartels *et al.* 1985.

DOWN LOGS ON LAND

As with snags, large diameter logs on the ground typically progress through recognized stages of decay (Figure 4). Different ecological functions are associated with each of these stages. Such logs may persist for up to 500 years. Down logs affect the composition of the forest by providing habitat for small mammals, amphibians, and invertebrates. They can also serve as a substrate for conifer regeneration (nurse logs), and a site for mycorrhizal activity. A key habitat feature of down logs for all these species is the moisture-holding capacity of these large, porous structures.

Coarse woody debris may serve an important function in forest nitrogen cycles, initially as a sink, but ultimately as a long-term source. Nitrogen concentrations increase as the wood decays, and some asymbiotic nitrogen fixation also occurs.

LARGE LOGS IN STREAMS

The role of large logs in streams is discussed below under riparian ecosystems.

Wildlife habitat

Research on wildlife habitat in forests has shown that the middle seral stages of forest development generally provide the least overall habitat value. In contrast, the early and late seral stages support more wildlife species (Figure 5). Moreover, the late seral stages provide habitat for a number of wildlife species having specialized adaptations to conditions which only occur late in forest succession. Examples of species strongly associated with old-growth include the Northern Spotted Owl, the Pileated Woodpecker, the Pine Marten, and the Pacific Giant Salamander (Fenger and Harcombe 1989).

Principles and practices of new forestry

However, conventional forestry practice, with its emphasis on timber production, has sought to shorten the early stages of succession by getting the conifer crop trees established as soon as possible, and to eliminate altogether the later successional stages by harvesting managed stands some time around the culmination of mean annual increment, before old-growth conditions can develop (Figures 11A and B). Species that depend on old-growth are expected to decline under intensive forest management.



FIGURE 5. Ordination of western Oregon mammals along a successional gradient. Source: Harris 1984.

Bunnell (1990) notes three reasons for which species may prefer old-growth habitat: structural heterogeneity, large piece size, and age. He suggests that the first two may be created in managed forests by appropriate silvicultural methods.

Biological legacies and ecosystem recovery

Although a great deal of forest research has concentrated on regeneration in managed forests, until recently, little had examined how forest ecosystems recover from natural disturbances.

Researchers studying stands disturbed by fire, windstorms, and other natural disturbances (such as the volcanic eruption of Mount St. Helens [Franklin *et al.* 1985]) have noted the role played by remnant living organisms and dead organic structures (snags and down logs) in ecological recovery of the disturbed site (Figure 6). These observations have led to a questioning of the widely held belief that clearcutting mimics a natural disturbance. They have also stimulated interest in the designing of similar "biological legacies" into management disturbances such as logging.

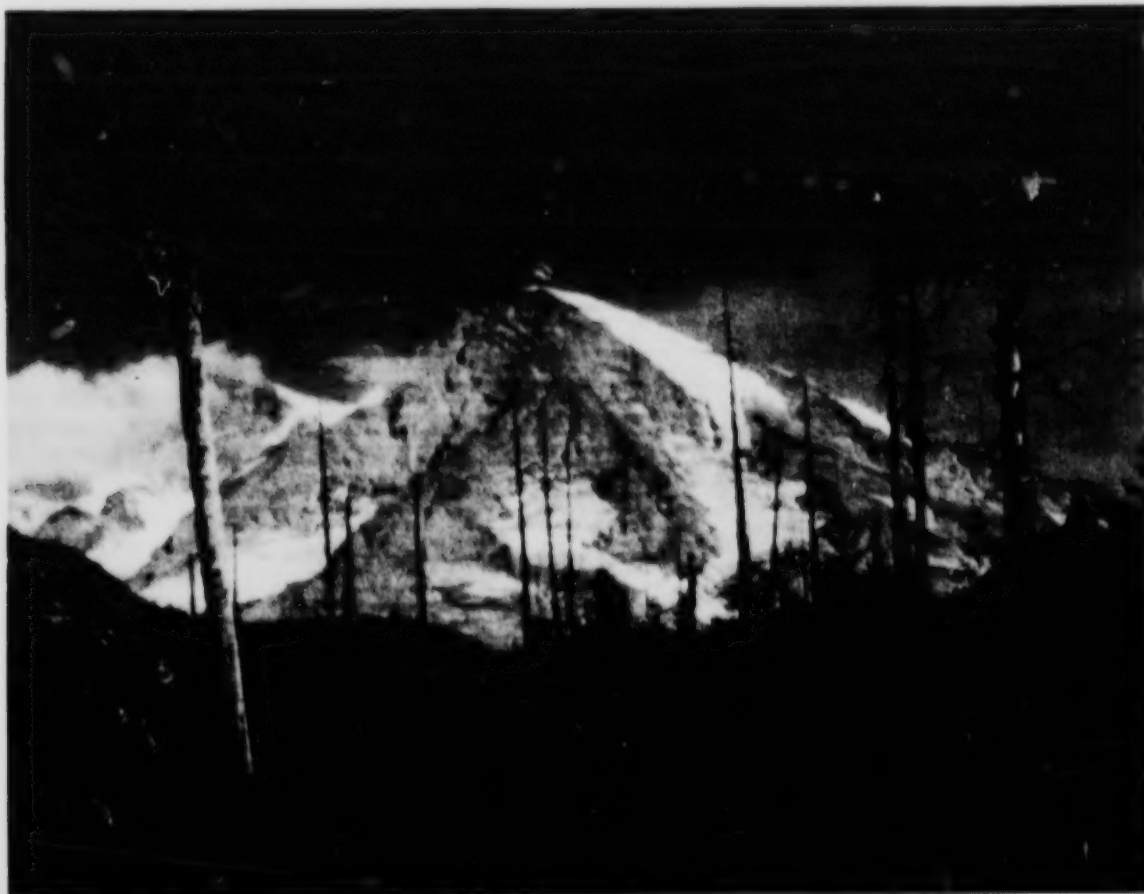


FIGURE 6. Ecosystem recovery following wildfire, Mount Rainier, Washington. "Biological legacies," such as snags and down logs, play a role in recovery from natural disturbances.

Long-term productivity

Other ecosystem research in the Pacific Northwest has looked at soil biological processes and the roles of various organisms in maintaining site productivity. The existence of symbiotic nitrogen-fixing organisms associated with such plants as red alder, ceanothus, and various legumes has long been known. Other non-

symbiotic sources of N-fixation have more recently been discovered in connection with arboreal lichens in the canopies of old-growth Douglas-fir trees (Denison 1979), in large down logs on the forest floor (Harmon *et al.* 1986), and in the rhizosphere (Perry *et al.* 1987). Such processes may be important, given the concern that intensive forest management may deplete forest nutrient capital to the point of lowering site productivity (Kimmins 1977; Perry 1987).

As with the N-fixing organisms, the importance of mycorrhizae to forest productivity has been known for some time. Again, however, new research is revealing a greater complexity of process than was formerly appreciated. For example, Amaranthus (1990) reports that broadleaf plants (Manzanita) left on a site following clearcutting could serve as alternate hosts for beneficial mycorrhizae, and thus facilitate regeneration of conifers on the site.

Another example of unexpected linkages in forest ecosystems involves coarse woody debris, small mammals, mycorrhizae, and asymbiotic N-fixation. Maser *et al.* (1978) describe the role of the Western Red-backed Vole, a small arboreal mammal, in inoculating tree seedlings with mycorrhizal spores. This animal's dietary staple is the underground fruiting bodies of certain mycorrhizal fungi (truffles). The vole's fecal pellets contain mycorrhizal spores, a yeast, and N-fixing bacteria. When the animal defecates in the vicinity of a seedling, it provides the necessary inoculum to initiate a complete rhizosphere community around the seedling. The vole depends on coarse woody debris in the forest for its habitat.

Although other researchers discount the importance of this process to forest management, I believe this kind of information about ecosystem complexity has implications outside timber management. Given that U.S. National Forests must, by law, be managed for biological diversity, understanding of such processes is certainly important. Also, it would appear that this new appreciation of ecosystem complexity, which stands in sharp contrast to the formerly wide-spread notion of old-growth forests as "biological deserts," contributes to the public feeling that Pacific Northwest old-growth forests are particularly worthy of protection. There is again a parallel between tropical and Westside forests, in the growing conception among the public that these are wonderfully diverse and fragile ecosystems which may be lost forever before their full complexity is understood.

Some scientists and foresters believe that new discoveries of complexity in forest ecosystems demonstrate the incompleteness of our present understanding. The fact that many ecosystem processes were only recently discovered suggests that other important processes may still be undiscovered. Part of the philosophy of New Forestry is an attitude of humility in forest management, given our incomplete knowledge (Franklin *et al.* 1989). The argument for retaining ecosystem elements with unknown functions was best expressed by Leopold (1966): "If the biota in the course of aeons has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first rule of intelligent tinkering."

Landscape ecology

Landscape ecology is a young science concerned with the long-term dynamics of ecological communities over large spatial scales (Forman and Godron 1986). The application of landscape ecology in Westside forests has stimulated a major re-evaluation of the effects of timber operations in National Forests. Much of the incentive for researchers to expand their thinking beyond the scale of the individual stand came from the study of wildlife species with large home ranges, such as elk or grizzly bear (Franklin 1990). The hydrologic effects of forestry practices also led researchers to consider large spatial scales.

A major concern of conservation biologists world-wide is that of habitat fragmentation. Fragmentation occurs "when a large expanse of habitat is transformed into a number of smaller patches of smaller total area, isolated from each other by a matrix of habitats unlike the original" (Wilcove *et al.* 1986). Fragmentation can be a cause of extinctions. The implications of forest fragmentation for wildlife species of the Westside was analysed by Harris (1984). Until recently, forest managers in the National Forests followed the "dispersed patch clearcutting" or "staggered setting" approach to the scheduling of timber harvests on the landscape (Figure 7). This approach led quickly to a high degree of forest fragmentation (Franklin and Forman 1987), so that much of the old-growth remaining in the National Forests is distributed in small patches (Figure 8).

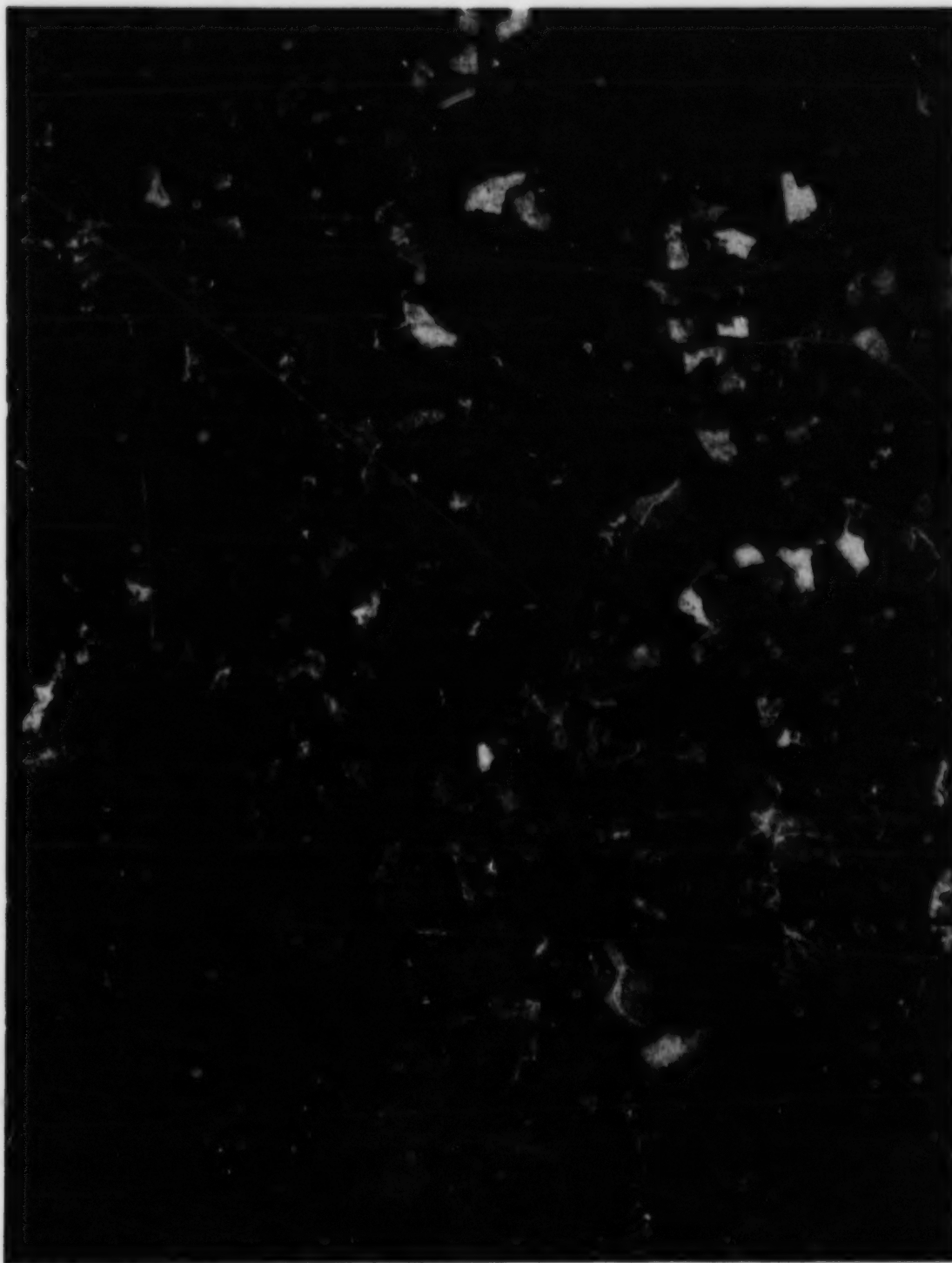


FIGURE 7. Infra-red air photo mosaic showing dispersed patch clearcutting, Blue River Ranger District, Willamette National Forest, Oregon.

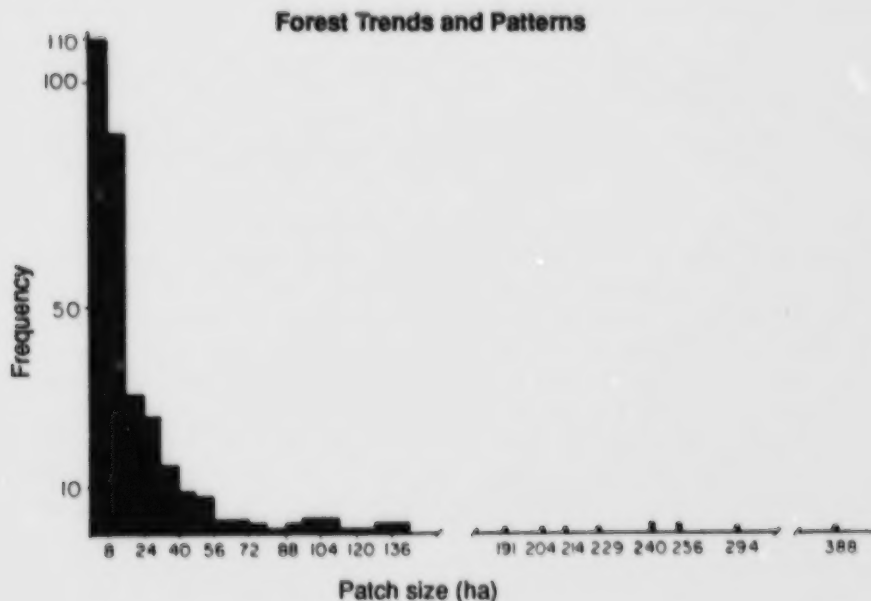


FIGURE 8. Size class distribution of the 319 remaining old-growth stands in the Siuslaw National Forest. Source: Harris 1984.

Another aspect of fragmentation concerns "edge effects." Forest wildlife managers have traditionally considered the forest edges created by timber operations to be beneficial to wildlife, noting the increased abundance of certain game animals in these habitats (e.g., Thomas *et al.* 1979). However, edge effects may adversely affect some species which require forest interior habitat. If edge effects extend a significant distance into a small remnant patch of old-growth, there may be little or no true forest interior habitat left. As a rule of thumb, "three tree heights" has been suggested for how far climatic effects will extend from a clearcut into an old-growth stand (Harris 1984).

Some studies have investigated the relations between forest management and the propagation of various natural events through the landscape, such as fire, insect pest outbreaks, forest diseases, and windthrow. For example, the spread of several forest pests including Port Orford cedar root rot, black stain root disease, and gypsy moth has been facilitated by the construction of the extensive logging road network required by the staggered setting approach used on the Westside (Perry 1988).

Other studies in hydrology and geomorphology have looked at the cumulative watershed effects of logging, which may produce floods (Grant 1990) or changes in stream temperature (F. Swanson, USDA Forest Service, personal communication).

The general lesson from landscape ecology is the need to "integrate individual activities at larger spatial and longer temporal scales" (Franklin 1990).

Riparian ecosystems

As with much of the scientific background of New Forestry, knowledge of the importance of riparian ecosystems is not new. However, recent research has revealed a greater depth of ecological complexity than was previously recognized. For example, large fallen logs in streams provide important long-lived structures that diversify and stabilize the aquatic habitat by creating pools and reducing erosion (Swanson *et al.* 1976). The surrounding forest ecosystem is needed as a long-term source of such logs. Forests also provide the energy base for smaller streams in the form of litterfall, and provide shade to modulate water temperatures.

Ecological stress and resilience

Human induced changes in the environment have been implicated in the phenomenon of "forest decline," especially in central Europe and eastern North America. Such factors as acid precipitation and increased tropospheric ozone levels have been identified as agents of stress in forest ecosystems. Climate change is predicted to add to such stresses in the future. Ecologists speculate that the complexity typical of natural forests may confer greater resistance to such stresses than would exist in the simplified ecosystems of intensively managed forests (Franklin *et al.* 1989).

Some researchers hypothesize that many ecosystems derive stability from internal positive feedback mechanisms, and may be vulnerable to rapid deterioration if subjected to foreign disturbances (Perry *et al.* 1989). For example, in many environments, plant regeneration following disturbance requires the presence of below-ground mutualists, such as mycorrhizal fungi. The fungi in turn depend on the green plants for energy. If a disturbance (such as logging) removes the plant component of the system, the fungus component will decline, in some cases quite rapidly. Plant regeneration is thus impaired, resulting in further decline of the fungus. This positive feedback loop can then lead to continued deterioration of the system. The suggestion is made that by emulating the natural disturbance regime, to which the system is adapted for recovery, resource managers may avoid pitfalls of this kind.

Biological diversity

LEVELS OF BIODIVERSITY

Biological diversity ("biodiversity" for short) refers simply to the diversity of living beings. Biodiversity is a subject of major and increasing concern amongst scientists for several reasons:

1. our present knowledge of the world's biodiversity is very incomplete;
2. world-wide biodiversity is being rapidly lost; and
3. techniques for conserving biodiversity are poorly developed.

Biodiversity exists at all levels of biological organisation, but is most commonly recognized at the following levels: genetic, subspecies, species, and ecosystems. Diversity is also recognized over various spatial scales. Alpha diversity refers to the diversity of species within a given community; beta diversity refers to the diversity of communities over a larger area of landscape. Gamma diversity refers to the total diversity over a large region. Various quantitative measures exist for biodiversity which can be applied at any of these levels.

CONSERVATION OF BIODIVERSITY

Biological diversity is lost when species, subspecies, or ecotypes become extinct or locally extirpated. The present global rate of loss of biodiversity is extraordinarily high (Wilson 1988), and is primarily due to habitat destruction caused by human activities. Many arguments exist for conserving biodiversity, most of which fall into the two broad classes of "utilitarian" and "inherent value." Bunnell (1990) distinguishes and discusses some finer distinctions within these classes.

Although biodiversity is defined most crudely as the total diversity of life on earth, local conservation efforts are often more finely focused. Soulé and Simberloff (1986) note that conservation efforts may be aimed at biological diversity *per se* (maximum number of species), or at protecting rare, endemic, threatened or endangered species, or at conserving entire functioning ecological communities. Conservation strategies will vary among these three goals. Although individual species may be preserved (at least for a period of time) in zoos or gardens, conservation of whole communities usually requires the creation of reserves: areas in which human activities are controlled so as not to degrade the habitat.

The basic questions of reserve design -- how many, how big -- have received considerable debate. Simple answers have not emerged. According to Soulé and Simberloff (1986) the problem "is no less complex than population biology itself." However, they and others (Bunnell 1990) conclude that reserves should be both large and numerous, especially where conservation of ecological communities is the goal.

The finer questions of reserve design -- such as shape, habitat heterogeneity, and the role of corridors -- appear to be most suitably addressed with reference to the particular adaptations of the entity to be conserved.

To summarize the background to New Forestry: the high demand for both timber and other resource values from public forest lands on the Westside has caused a broadening of multiple use management objectives. At the same time, greater ecological understanding of these forests has stimulated a major rethinking of forestry practices.

New Forestry and New Perspectives

The terms "New Forestry" and "New Perspectives" are sometimes used interchangeably, which is not quite correct. New Forestry, although not formally defined anywhere, refers to an ecologically oriented approach to forestry developed primarily in the Pacific Northwest region, as described above. New Perspectives is a 2-year program of the USDA Forest Service at the national level, intended to re-orient the Forest Service towards more holistic, ecosystem-based forest management, and to re-vitalise the Forest Service's commitment to land stewardship that serves the general public (Sallwasser 1990). As such, New Perspectives may involve the use of New Forestry practices (such as green tree retention, riparian buffer strips, and landscape level planning to reduce fragmentation) where appropriate, but New Perspectives also includes a commitment to general environmental conservation throughout the National Forest system, and greatly increased public participation in forest land use planning.

Although New Forestry has been developed primarily on the National Forests, its principles are also being applied to various degrees on other ownerships, as will be discussed later.

III NEW FORESTRY PRACTICES

As was mentioned above, forestry practices are usually designed or adopted to achieve particular objectives. Many New Forestry practices arise from a balancing of numerous complementary (or sometimes conflicting) objectives. In fact, where traditional forestry practices were often designed to simplify forest ecosystems, the explicit goal of New Forestry is to re-introduce complexity and diversity into managed forests. This may help to explain the somewhat "fuzzy" connection between objective and practice in New Forestry, which may trouble those accustomed to a tidier school of forestry.

Advocates of New Forestry do not propose to replace conventional forestry practices with an entirely new set of practices. Rather, the idea is to add some new "tools" to the foresters "tool-kit," so that a broader range of objectives can be met.

Practices and Prescriptions

In considering New Forestry it is useful to make a distinction between practices and prescriptions. In forestry terminology, a "practice" can be defined as the general case of a certain management treatment or action. A "prescription" denotes a site-specific set of instructions for the execution of a practice. For example, "pre-commercial thinning" is a forestry practice, but a prescription for pre-commercial thinning might specify criteria for selection of trees, a target density, and other information with particular reference to the stand to be treated. This distinction is important in the evaluation of the applicability of New Forestry to British Columbia.

Spatial Scale

The discussion of New Forestry is frequently divided into stand-level and landscape-level practices. This division is convenient and I will use it here, but it is important to remember that in ecological forest management all spatial and temporal scales are important and interconnected.

The stand-level and landscape-level practices of New Forestry are intended to work together towards the overall objective of maintaining a high level of ecological diversity, complexity, and resilience in the managed forest. For example, managing stands on extended rotations has been proposed — as a stand-level practice — to permit the development of greater structural diversity within individual stands. But extending the rotation can also be seen as a landscape-level action, because it will control the distribution of different seral conditions across the landscape, which may be a key factor in preserving biological diversity in managed forests (Harris 1984).

Stand Level Practices

Structure, function, and composition

The general principle of New Forestry stand management is to maintain a structurally complex stand. However, structural complexity should not be considered an end in itself. As discussed previously, the structural characteristics of old-growth forests are believed to influence composition and function. Frequently, the ultimate goals in forest stand management are concerned with composition or function (maintaining wildlife populations or nutrient cycles, for example). Manipulation of stand structure is undertaken as the means to those ends.

Silvicultural systems

A program for the treatment of a stand during a whole rotation is called a silvicultural system (Smith 1986). Although New Forestry is sometimes referred to as a silvicultural system, it should more correctly be thought of as a philosophy of forestry — one which will influence the design and selection of silvicultural systems. Many of the silvicultural systems used in New Forestry are similar to conventional systems. Appendix 2 describes the range of silvicultural systems that were considered for application on the Shasta Costa Project of the Siskiyou National Forest in southern Oregon, and it provides an overview of the kinds of silvicultural systems that are compatible with New Forestry goals in the Douglas-fir region.

Some of the silvicultural practices of New Forestry are expected to produce lower timber yields than are conventional practices (Atkinson 1990; Franklin 1990). Empirical data on this effect are not available, but several estimates have been made using simulation models. A discussion of the yield implications of the different systems is provided in Appendix 2.

The most commonly used New Forestry silvicultural systems in Washington and Oregon are those of Light or Medium Conifer Retention, which are similar to conventional seed tree or shelterwood systems, but also different in that the overstory portion of the stand is not removed after regeneration is secured. The desired result has been called a "sloppy clearcut".

It is worth noting that the selection silvicultural system, which has frequent light cutting entries, is not much used in New Forestry on the Westside. The philosophy of New Forestry does not preclude the use of this system, but because of higher road and logging costs, potential for damage to the residual stand, and a tendency to promote the less desired tolerant tree species rather than Douglas-fir, it is not considered the best system for many Westside forests (Isaac 1956; Franklin 1990).

The selection system is working successfully on small private woodlots on the Westside (Foss 1990), and has been prescribed for areas with high aesthetic or other special values (Siskiyou National Forest, Shasta Costa Draft Environmental Impact Statement 1990). It is also finding increasing use east of the Cascades, in areas where the desired crop tree species regenerate well under shaded conditions.

This next section covers stand-level practices of New Forestry currently in place or planned on the National Forests of the Westside. New Forestry practices in other regions or under other ownerships is covered under a separate heading below. This discussion of management practices is organized to follow the chronological sequence of events that occur over the life-span of a managed stand.

Harvest

One important objective of harvesting under New Forestry is to retain more of the structural features of the old stand to carry over into the new stand — that is, to retain and create biological legacies. These features may include down logs, snags, large live trees, hardwood trees, and various understory trees and plants. In some cases, quantitative standards or guidelines have been set for the retention of such features, usually by a process of consultation between scientists and managers. Depending on the availability of data, such standards may be set subjectively (Puleo 1990) or, for example, by modelling and extrapolation of known animal habitat requirements (Neitro *et al.* 1985; Eubanks 1990).

DEAD AND DOWN LOGS

Down logs are desirable for a number of reasons, including their role as small mammal habitat, their moisture-holding capacity which may assist regeneration, and their role in nutrient cycling, serving as a site for mycorrhizal activity and asymbiotic N-fixation (Harmon *et al.* 1986).

The practices of yarding unmerchantable material and piling unmerchantable material were once common on the Westside, but have now been largely discontinued. Some forest districts have set guidelines for target amounts of coarse woody debris to be left after logging. The Blue River Residue Guideline is illustrated in Figure 9.

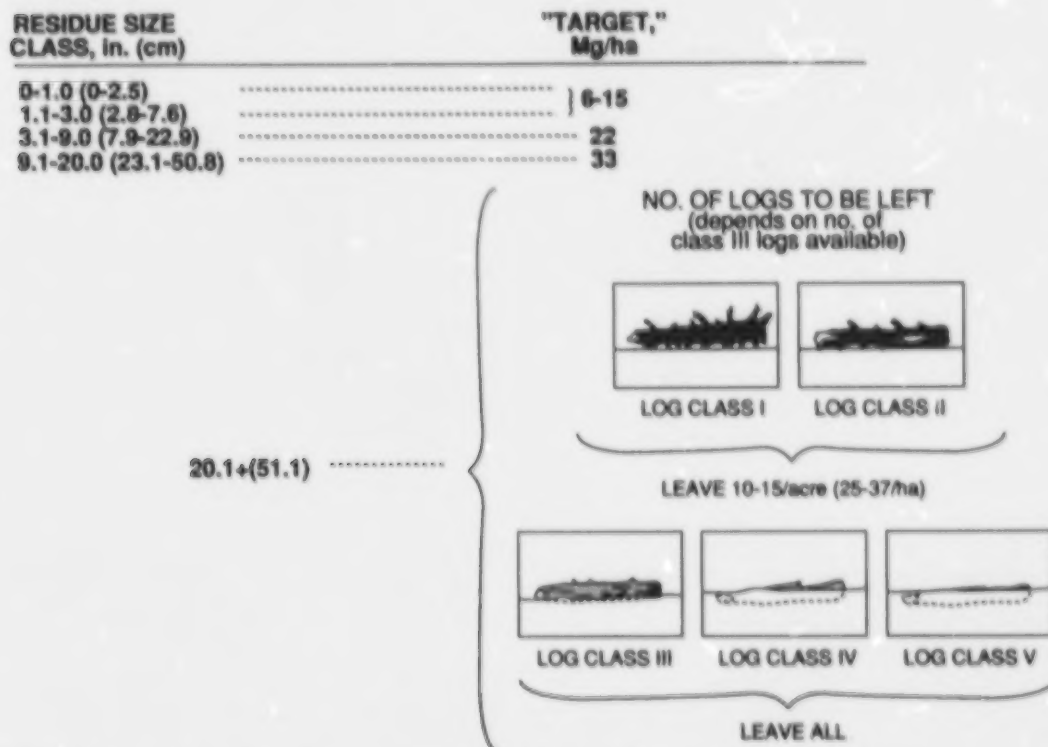


FIGURE 9. The Blue River Ranger District Residue Guideline. Source: Eubanks 1989.

SNAGS

Snags are an important habitat element for a large number and variety of wildlife species, including woodpeckers, owls, eagles, various songbirds, bats, raccoons, black bears, and small mammals (Neitro *et al.* 1985). They also provide a future source of down logs.

A wide variety of different approaches has been used to ensure the presence of snags in regenerated stands after logging. Some districts have required a certain number of snags per acre to be left, selected either by Forest Service markers or by the fallers.

In some cases, residual snags have been fairly uniformly distributed on the site (Figure 10); in others they have been grouped in clumps (sometimes with green trees), or concentrated near the boundaries of the setting or in lines along the spokes of cableways. Clumped distributions are generally considered good for safety and wildlife concerns, but less desirable given the role of snags as future down logs.

An important concern with leaving snags is the safety of the logging crews, who may be injured or killed by snags that fall as a result of ground vibration or disturbance by logging cables or machines. To reduce these hazards, snags are often not retained in critical areas, such as close to landings and roads. Grouping of snags near the edges of a cutting unit reduces the danger. Guidelines are available to help in assessing the safety of individual snags.

Because of the safety issue, many districts are meeting their snag objectives by retaining green trees (preferably ones of poor form or quality), which are safer to work around. These can be converted to snags later by poisoning, girdling, or topping either by saw or explosives. The method chosen influences the subsequent pattern of decay, which can be matched to specific habitat objectives. For example, trees killed by girdling may tend to rot from the outside in, and fall before the heartwood is well decayed. This provides little excavating opportunity for cavity-nesting birds, but quickly creates foraging opportunities for insectivores. Trees killed by blasting the tops will follow the more "natural" succession of heartwood decay, standing longer and providing more cavity-nesting habitat.

GREEN TREES

Green trees can perform a wide range of functions on a cut-over site. As animal habitat they provide nesting, foraging, or roosting sites for birds. They may also provide refugia for invertebrate predators — some of which disperse poorly and might be slow to recolonize a clearcut area (Franklin 1990). Their functions relating to regeneration include modifying microclimate, providing a seed source, and providing hosts for mycorrhizal fungi. Later in stand development, green trees can be converted to snags and coarse woody debris, or can help to provide the kind of vertical structural heterogeneity of the canopy typical of old-growth. Some researchers hypothesize that this would accelerate the development of suitable habitat for old-growth dependent species (such as Spotted Owls) in managed stands (Franklin 1990). If not converted to snags, green trees could provide a source of high-quality large-diameter logs at the next rotation.

Harvesting prescriptions requiring the retention of four or more green trees per acre (9 trees per ha) are becoming common throughout the Westside, and are more the rule than the exception in some National Forest Ranger Districts. For example, the Forest plan of the Siskiyou National Forest calls for a minimum of 185 trees per 100 acres to be converted to snags after logging. Since these snags cannot be expected to last the full rotation, an equal number of trees are left to be converted later in the rotation. After a certain period, new snags can be recruited from the regenerated stand (P. Soderquist, USDA Forest Service, personal communication). This level of retention (around 4 trees per acre) corresponds to the Light Conifer Retention silvicultural system described in Appendix 3. Moderate Conifer Retention might require an average of 10 trees per acre, and Heavy Conifer Retention up to 20 trees per acre. The level of retention chosen depends upon specific stand conditions (tree diameters, crown widths, etc.) and stand objectives (habitat value rating, visual management objectives, etc.) If natural regeneration is intended, trees must also be selected for apparent genetic suitability.

Windthrow of leave trees has been a problem on some cutting units, although many managers claim they are developing better skills in selecting windfirm trees, according to both the individual tree's characteristics and its environment (topographic placement, soil depth, etc.). Topping has been used successfully to reduce the windthrow susceptibility of retention trees. Generally, some amount of windthrow is regarded as unavoidable, but given the desire for coarse woody debris on the site, it is not regarded as a complete loss.



FIGURE 10. Recently logged setting, Blue River Ranger District, Willamette National Forest, Oregon. Various sizes and species of snags and green trees have been left standing. Some large down logs are left on the site; some slash was yarded or hand-piled for burning. This site was later planted with a mixture of conifer species.

HARDWOODS AND UNDERSTORY SPECIES

As with green tree retention, many harvest prescriptions now call for retention of hardwoods such as bigleaf maple and understory conifers such as yew, to increase overall diversity and possibly benefit some wildlife species. The recent interest in yew as a source of a potential cancer drug has been cited as an argument against eliminating any components of the ecosystem which may possess undiscovered virtues.

LOGGING METHODS

Leaving snags or green trees standing presents a logistical challenge to loggers. The most commonly used logging systems for green tree retention are skyline cable systems with lateral yarding capabilities. Loggers estimate that conifer retention logging costs with these systems are 15–20% higher than with clearcutting.

In some cases, no extra costs are involved. On one 106-acre setting on the Olympic Experimental State Forest, the logging contractor, using hoe-chucking,¹ was able to leave four snags per acre plus some green trees in a range of sizes. From the safety point of view, this method has the advantage of requiring no rigging crew workers (choker-setters) on the ground, and the machine operator can test the stability of the snags by "nudging" them with the boom.

Regeneration

SITE PREPARATION

The objectives of site preparation under New Forestry are to permit regeneration of the site and reduce fuels, while leaving coarse woody debris and not killing green retention trees. Generally, there has been a trend away from PUM and YUM (piling unmerchantable material, and yarding unmerchantable material) and broadcast burning. (Some reduction of slash-burning has resulted also from smoke control considerations.) Some yarding of smaller slash may be done, as well as hand-piling and spot burning.

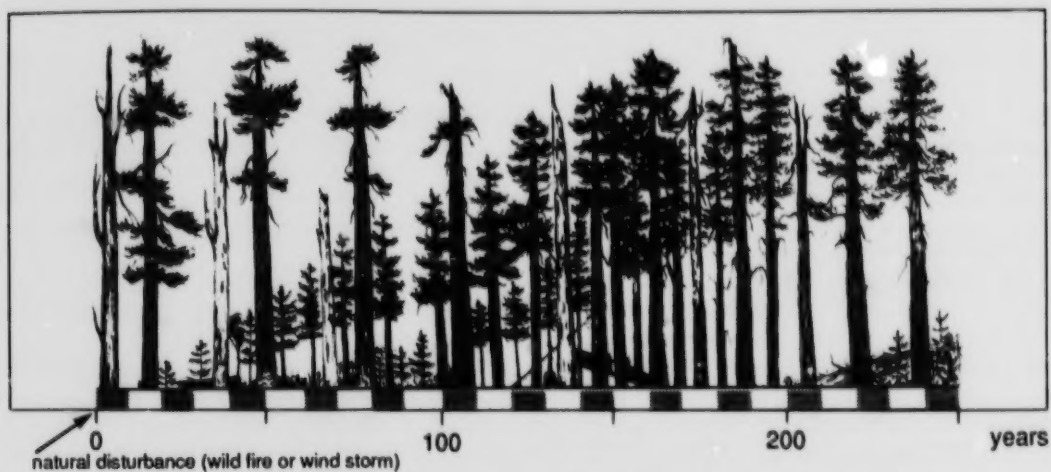
REGENERATION

Regeneration may be accomplished either naturally or by planting. Green tree retention enhances the feasibility of natural regeneration, which may be considered desirable for the preservation of local genetic variation. Nevertheless, planting reduces the risk of regeneration delay and permits more control over stocking density, species composition, and genetics, so planting is frequently done with green tree retention.

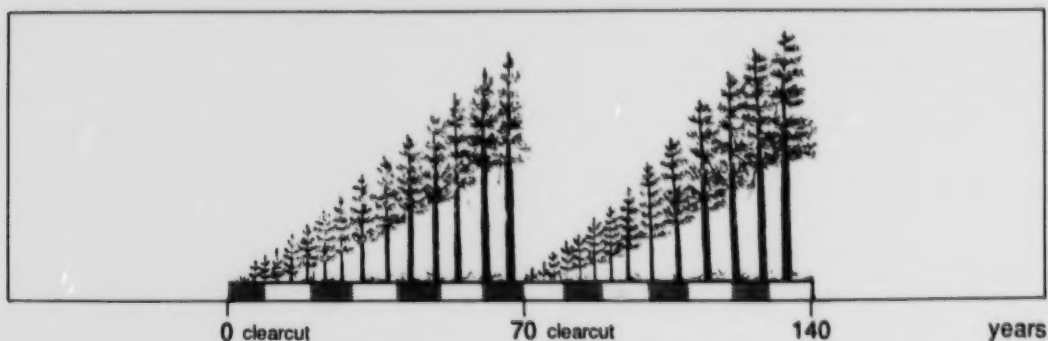
In addition to the conventional forestry objective of establishing a new crop stand, New Forestry regeneration objectives may include the delaying of canopy closure to extend the ecologically rich early seral stages of succession and the creation of a structurally and compositionally diverse stand. Canopy closure can be delayed by trees being planted at wide spacings. Planting prescriptions of 4.6 × 4.6 m (480 trees per ha) are common, and even 5.5 × 5.5 m (330 trees per ha) is not unusual. Advocates of wide spacing suggest that little sacrifice of volume will be required and that, with pruning, high quality logs can be produced. It has also been suggested that the larger tree sizes that can be produced with wide spacings provide a way to develop conditions similar to those for old-growth in less time than needed in natural stands (DeBell 1989). Another option for extending early seral stages is to plant trees in clumps with spaces between (Hemstrom 1990).

Ecological diversity can be increased through the regeneration of a mixture of species. Some examples of mixtures used on the Westside include Douglas-fir mixed with red alder, western redcedar, or western white pine. Some benefits of mixtures may include soil fertility improvement or increased yields (DeBell 1990), or increased resistance to insect pests (Schowalter 1990).

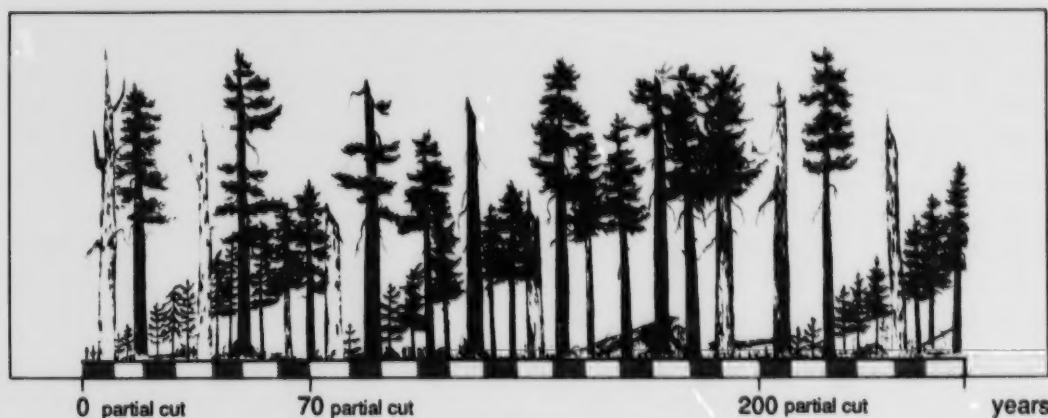
¹ Hoe-chucking is a logging method using the boom of a track-mounted excavator to move logs. The machine makes parallel traverses across the setting, picking up logs and swinging them towards the landing or road.



A. Natural recovery following a moderate intensity disturbance such as wildfire or windstorm.



B. With intensive management for timber production, the early seral stages are shortened, and the later seral stages with their associated structural features are eliminated.



C. The stand-level practices of New Forestry are designed to emulate some of the structural diversity found in unmanaged forests. Practices illustrated include snag and green tree retention, mixed species regeneration, long rotations, and creation of snags by topping green trees.

FIGURE 11. Temporal development of forest stands.

Stand development

Since most of the practices of New Forestry have only been in use for less than 5 years, discussion of post-regeneration stand treatments is somewhat hypothetical. However, various treatments have been planned or proposed in keeping with New Forestry objectives.

VEGETATION MANAGEMENT

Given the objective of maintaining a diverse stand, New Forestry may place less emphasis than other approaches on control or elimination of non-crop vegetation. Noting that deciduous brush species account for a major input of nitrogen to some forest ecosystems, several researchers suggest that eliminating these species may have negative impacts on long-term productivity (Perry 1987). On the other hand, it has also been noted that New Forestry practices may increase the risk that competing vegetation will impede conifer regeneration and growth (Atkinson 1990).

An example of a New Forestry approach to vegetation management is provided by the Willamette National Forest Management Plan (1990) Standards and Guidelines, which require that:

1. no native species be eliminated from a site; and
2. native species targeted for removal from a site be retained to at least 10% of the number of individual plants and their spatial distribution before treatment.

INTERMEDIATE CUTTING

Heavy pre-commercial thinning has been proposed as one means of maintaining early seral species in the understory, and also of accelerating the development of large individual trees. Commercial thinning is planned for many stands, but as a general principle, frequent entries into Douglas-fir stands of the Westside are not considered desirable.

ROTATION LENGTH

Long rotations have been proposed as a means to integrate wildlife and timber management objectives, by permitting development of late seral conditions. For example, in the Siskiyou National Forest, rotation lengths of 130–250 years have been planned for sites where the rotation for maximum volume (culmination of Mean Annual Increment) would be 90–100 years (P. Soderquist, USDA Forest Service, personal communication).

The practices described above can be used in various combinations or in conjunction with certain conventional practices. Their application is not limited to old-growth stands. Most importantly, they can and should be modified in accordance with site and stand-specific conditions and objectives.

Landscape Level Practices

The general principle of New Forestry at the landscape level is to integrate forest activities at longer temporal and larger spatial scales (Franklin 1990).

The main goals that have been identified for the landscape level management in the Westside are: the maintenance of biological diversity (especially threatened and endangered species); the management of economic fish and wildlife populations, such as salmonids and big game animals; and the control of the cumulative watershed effects on hydrologic and geomorphic processes, such as stream temperature and sediment loads, erosion, and flooding.

Biological diversity

The U.S. Department of Agriculture policy (USDA 1980) identified two major approaches to wildlife management. One is to manage indicator or featured species; the other is to manage species richness or ecosystems. Indicator and featured species are not exactly the same. Under the featured species approach, one wildlife species is selected for emphasis on a unit of land. Big game animals such as deer and elk have often been chosen as featured species for wildlife management in the Pacific Northwest. An indicator species is one whose habitat requirements are considered to be similar to those of a number of other species. For example, management to provide suitable habitat for Pileated Woodpeckers would probably benefit other cavity-nesting species as well (Brown and Curtis 1985).

New Forestry favours the ecosystem approach, which seeks to maintain overall biological diversity. Nevertheless, practical methods of ecosystem management are not well developed. Therefore, managers have often chosen to focus on threatened and endangered species, both for the conservation of those species *per se* and as indicator species. In the context of Westside forests, this has focused attention on old-growth dependent species. The Northern Spotted Owl in particular is a species to which much management effort has been directed.

Reserved areas play a key role in the landscape approach to maintaining biological diversity (Harris 1985). In one sense, landscape-level New Forestry is concerned with deriving the greatest ecological return from a given investment in reserved areas, by ensuring that the reserved areas are effectively situated in the landscape. This effectiveness depends on:

1. the choice of appropriate forest habitat types for reserves;
2. size and shape of the reserves, which control the edge/interior habitat ratio;
3. the kinds of connections and corridors that exist to permit dispersion between reserves; and
4. the characteristics of the non-reserve lands adjacent to the reserves. In New Forestry reserves are seen as "a network, and as a part of rather than apart from the commodity landscape" (Franklin 1990).

Maintaining effective landscape patterns over time adds an extra element of complexity to the problem, as timber harvests, succession, and natural disturbances alter the individual landscape elements.

Fish and wildlife

Fish habitat concerns are discussed under watershed effects. Landscape level concerns for the management of big-game habitat often involve the design and layout of harvest units to provide a balance of forage and cover connected by riparian corridors, or the planning of road locations to reduce human disturbance of populations (Witmer *et al.* 1985).

Cumulative watershed effects

Landscape-level concerns for hydrologic and geomorphic processes include controlling the cumulative effects of forest operations on stream temperatures, sediment loads, and peak flows, which in turn can affect channel stability, riparian zones, and aquatic habitat.

Research indicates that logging can influence the vulnerability of Westside streams to increased peak flows resulting from rain-on-snow events (Harr 1986). Theory suggests that the magnitude of this effect can be controlled by controlling the proportion of the landscape within the transient snow zone that is in cut-over or early seral conditions. Similarly, stream water temperature (a critical fish habitat parameter of many Westside streams) must be managed in a watershed context to control warming caused by removal of shading vegetation (Everest *et al.* 1985), because temperature in higher-order streams is a function of the area of unshaded water in the smaller tributary streams.

Landscape-level planning

In practice, the objectives that have most recently dominated the landscape-level planning process in Westside National Forests are those set by Section 318 of the 1990 U.S. *Federal Appropriations Act*. These required the managers to minimize the impact of timber harvesting on the most ecologically significant old-growth and the habitat of the Northern Spotted Owl. In response to this challenge, forest managers have developed planning tools using GIS (Geographic Information Systems) to identify which areas are suitable for timber harvest, and which are most critical to preserve.

Typically, landscape-level planning to meet Section 318 requirements has been done over watersheds ranging from 10 000 to 50 000 ha in area. The process used on the Lowell Ranger District proceeds by these steps:

1. Develop a stand type map. Several classes of stand are recognized on the basis of their "old-growth structure," according to such characteristics as tree size, presence of snags and down logs, and canopy structure (Old-Growth Definition Task Group 1986). Streams and drainage boundaries are also mapped.
2. Group old-growth stands into blocks. The "interior habitat" areas are defined by buffering two tree heights (140 m) into the old-growth. Block boundaries are defined by interior habitat, by size, shape and continuity of the blocks, and by topography.
3. Rate blocks for old-growth significance. An arbitrary point system was devised to give numerical scores to each block. In addition to having old-growth structural features, high scores are given for large block size, blocks covering whole watersheds, and blocks with special ecological or recreational/aesthetic features.
4. Develop a landscape management strategy. This process begins with a map showing reserved areas (e.g., Spotted Owl habitat areas, stream buffers) and high significance blocks. Building the landscape strategy proceeds with corridors being drawn in to connect the reserved and high significance old-growth blocks into a network.

Finally, alternative future harvesting scenarios can be simulated and selected on the basis of their effects on the landscape pattern. Appendix 3 describes this process in more detail. Many variations on this approach exist, and the models can be adapted to work with other criteria than old-growth habitat if desired.

An interesting point concerning the use of landscape planning to reduce fragmentation is that while some of the areas identified as high priority to retain are reserves (e.g., Spotted Owl habitat areas or unstable soil areas), others are simply deferred — that is, given low priority to harvest. This means that the desired network of old-growth will be maintained for some time, but is not permanently preserved. In some cases, for example, about 30 years of cutting at present levels can be accommodated before seriously jeopardising the network. The main reason for this planning exercise, therefore, is that it helps to maintain options for the old-growth resource. In 30 years, many things may be changed. Maturing plantation forests may reduce the pressure to cut old-growth, or foresters may have devised better ways to provide old-growth habitat conditions in managed forests. Changes in the climate or in economic and social conditions may radically alter forest management objectives. Planning to minimize the fragmentation of remaining old-growth now is done to preserve options and flexibility for the future.

Forest landscape planning is still in its infancy. In addition to the habitat fragmentation objectives discussed above, other projects in progress include predicting watershed-level hydrologic effects on peak flows (Grant 1990) and on water temperature (F. Swanson, USDA Forest Service, personal communication). Other applications to model the landscape dynamics of wind, fire, insect pests, disease, and genetic resources may be developed as knowledge of these processes increases.

Riparian management

New Forestry riparian management recognizes the high degree of connection between terrestrial and aquatic ecosystems that occurs in riparian zones. Stream ecosystems of the Westside depend on adjacent forest vegetation for:

1. a supply of energy and nutrients in the form of litterfall and insect material falling in the water;
2. shading to moderate temperatures; and
3. a long-term source of large organic debris (fallen logs) to provide structural heterogeneity to the stream channel.

All of these features may be important to providing habitat for anadromous fish and other aquatic organisms.

Riparian zones may also provide rich habitat for certain species of birds and small mammals (e.g., kingfishers, raccoons), and important migration corridors for big-game species such as elk. Riparian areas often have greater richness of plant species than do upland sites, and sometimes contain rare plants.

The general approach to riparian management under New Forestry is to leave larger buffer strips unharvested along streams. The widths of such strips vary with the size and structure of the stream. These riparian corridors are considered most effective if integrated with other reserve areas in the overall landscape design.

More information on riparian management under New Forestry is provided in Appendix 5, which contains excerpts from the Willamette National Forest Land and Resource Management Plan (1990).

New Forestry Practices in Other Regions and Ownerships

Alaska

Some significant research has been done in Alaska on old-growth characteristics, the dynamics of understory vegetation, and the responses of wildlife to silvicultural practices. Information of this kind is crucial in managing forests for biodiversity and non timber objectives. Some innovative silvicultural practices will soon be implemented on a trial basis, such as the use of small patch clear cuts. The feasibility of green tree retention is also being studied. (P. Alaback, USDA Forest Service, personal communication).

East of the Cascades

The New Perspectives program of the U.S. Forest Service is causing some re-evaluation of forestry practice in Oregon and Washington east of the Cascades (the "Eastside"), as in all regions of the United States. The Eastside forests have a different character from those of the Westside. In general, trees are smaller and stands are younger, partly as a result of fire and logging history associated with the early days of mining, ranching, and railway building, and partly because of the regional climate and soil differences. Some of the new practices planned on the Eastside include increased use of selection and shelterwood silvicultural systems, snag and wildlife tree retention, and some landscape-level planning around areas reserved for wildlife habitat.

Olympic Experimental State Forest

The Olympic Experimental State Forest (OESF) is on 246 000 acres (112 000 ha) of state-owned land on the west side of the Olympic Peninsula in Washington. The forests of this region are ecologically similar to those on the west coast of Vancouver Island. The OESF is managed by the Washington State Department of Natural Resources with the primary objective of earning money for the School Trusts. This mandate is in clear contrast to the multiple-use mandate of the National Forests. However, following the recommendation of the Commission on Old-Growth Alternatives for Washington's Forest Trust Lands (1989), the OESF has developed a draft management plan, which calls for management "for commodities and ecological values."

The OESF Draft Plan (1990) calls for extensive use of New Forestry practices. At the stand level, these include green tree and snag retention, target levels for down logs, mixed species regeneration, reduced use of burning and herbicides, and stand-tending practices to enhance wildlife habitat. At the landscape level, the plan calls for the use of watershed-scale planning to identify and (where deemed necessary) protect ecologically sensitive areas, and to maintain a network of riparian management zones across the landscape. Timber harvests from the forest will be gradually reduced to a sustainable level over a 10-year period. An "adaptive management" approach will be used in monitoring effects and modifying practices as needed.

The OESF draft plan is interesting in that it strongly affirms the importance of managing forests as whole ecosystems, even when the primary objective is to earn a financial return through timber operations.

Westside private industrial land

Although private industrial tree farms do not have a management mandate for multiple-use or biological diversity, some private land forest managers are interested in New Forestry practices. Private land managers are under some pressure to control the impacts of forestry operations on non-forest resources, particularly water, wildlife, and landscape aesthetics. This pressure is partly legal, under the Timber-Fish-Wildlife Agreement for example, and partly social, from environmental groups. One timber company in western Washington practices green tree and snag retention on about 20% of its cutting units. It also may designate habitat conservation areas and leave streamside buffer strips wider than the required 8-m minimum (P. Bialous, Plum Creek Timber Co., personal communication). In general, the approach to managing for ecological values on private land follows the pattern suggested by Atkinson (1990) of "modified plantation forestry," rather than New Forestry.

Central Europe

Most central European forests are made up of numerous, privately owned small holdings. Individual stands are very small by North American standards, and no virgin stands exist. The original natural forest vegetation of much of central Europe was dominated by hardwood or mixed forests.

Despite these significant differences between the forests of central Europe and those of western North America, there are strikingly similar trends in the forest management taking place in central Europe, and those of New Forestry. According to Plochmann (1989), the methods of plantation forestry have come under increasing public criticism since the 1960's. There has been, he says, "the general reproach that forestry solely oriented towards the maximization of profit can no longer meet the expectations of society. That criticism came from different sectors of society, but mainly from four constituencies: Those concerned with recreation, the preservation of nature, the protection of landscape, and the protection of water resources." Also, foresters themselves became aware that monocultures of conifers not indigenous to the site created ecologically unstable conditions.

In response to these concerns, forest managers in central Europe are moving towards practices such as: mixed species stands with more use of indigenous species; rotations to optimise value rather than volume (averaging 120–140 years); partial cutting systems with natural regeneration; more snags and down logs; and minimum use of management chemicals (Plochmann 1989).

IV APPLICABILITY OF NEW FORESTRY PRACTICES TO BRITISH COLUMBIA

New Forestry practices have been developed to meet certain goals for management of forest resources with certain characteristics. The issue of whether these practices should be used in British Columbia depends on two general questions:

1. How similar are our forest management goals and our forest resources to those of the Pacific Northwest region? (See *Comparison of Goals and Resources* section.)
2. Given the resources and the management goals, how good are the scientific arguments for using New Forestry practices? (See *Scientific Basis of New Forestry Practices* section.)

Comparison of Goals and Resources

Goals

One important feature in common between most of British Columbia's forests and the forests where New Forestry originated is that both are publicly owned resources. A comparison of forest management goals between the two regions should look at the goals set by legal mandate, and at the cross-section of goals found among the owners of the forests—the general public.

LEGAL MANDATE

In Washington and Oregon, New Forestry has gained its greatest acceptance on the publicly owned lands of the National Forests and the forests managed by the Bureau of Land Management. These forests are managed with a specific multiple-use mandate, under legislation such as the *Multiple-Use Sustained Yield Act* or the *National Forest Management Act*. A similar multiple use mandate exists for the publicly owned forests of British Columbia under the *Ministry of Forests Act*.

New Forestry principles have been accepted to a varying degree on ownerships without a strong multiple-use mandate, such as the state forests, and the privately owned industrial forests.

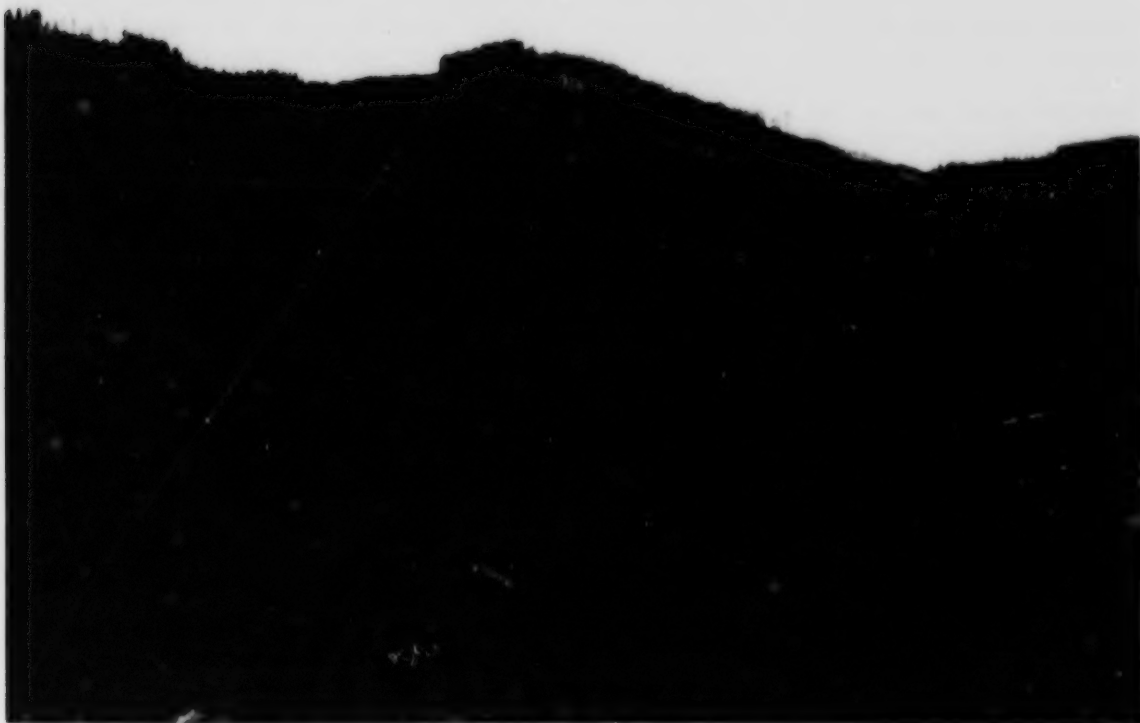


FIGURE 12. Typical industrial forest landscape in western Oregon. Old-growth stands have been mostly eliminated. Except for some deciduous species in young regenerating stands (middle), a near monoculture of Douglas-fir prevails.

Management for biological diversity is also a goal for both regions. The *National Forest Management Act* requires that Forest plans "preserve and enhance the diversity of plant and animal communities." Although there is no legal mandate to manage for biological diversity in our province, in response to changing public needs and expectations the Wildlife Program of the British Columbia Ministry of Environment revised its goals in 1987. Its new over-riding priority is the goal to "maintain and enhance wildlife and their habitats, and thus ensure an abundant, diverse, and self-sustaining wildlife resource throughout British Columbia."

SOCIAL GOALS

In both the Pacific Northwest and in British Columbia, public feeling is strong over the management of the publicly owned forests. There is evidence of a serious potential conflict between advocates of different goals for the management of the resource, especially between advocates of ecological or environmental values such as wilderness and wildlife preservation and advocates of the economic values of the timber industry. It appears that a majority of the general public favours more emphasis on protection of environmental values in the management of British Columbia's forests (Environics Research Group 1989).

One of the aims of New Forestry is to help in resolving this conflict, by devising practices that preserve more of the ecological values of the forest while permitting some timber extraction.

OWNERSHIP AND LAND USE PATTERNS

In addition to the similarity of goals for the public forests between British Columbia and the U.S. Pacific Northwest, some differences in the patterns of land ownership and allocation are worth noting. In Washington and Oregon, a high proportion of the total land base is in private industrial tree farms, while the majority of British Columbia's forest land is publicly owned.

In Washington and Oregon, past activities on the private forest lands have already eliminated many of the ecological values associated with old-growth forests. (Figure 12). These ownerships remain largely committed to conventional plantation forestry. Despite the different ownership pattern in British Columbia, a similar process of conversion of old-growth to managed forests is occurring here also. A significant proportion of the forest land base has been harvested, and committed to plantation forestry methods at least for the next rotation. In both cases the result is strong pressure to preserve ecological values in the remaining old-growth.

PROTECTED FORESTS

Another significant difference is in the amount of old-growth forest set aside from timber harvesting. West of the Cascades in Washington and Oregon, an estimated total of 535 400 ha are designated exempt from harvesting (Norse 1990), while the corresponding value for coastal British Columbia is 185 600 ha (Roemer *et al.* 1989).

Ecological resource comparison

Kimmins (1990) notes that New Forestry practices were designed for particular ecological conditions, and are probably only applicable to "that subset of British Columbia's forests that are ecologically similar to the forests of Oregon and Washington that were the source of the ideas and research."

A detailed ecological comparison of British Columbia and Pacific Northwest forests is beyond the scope of this report. However, I will propose a general framework for considering the question of ecological comparison and the "portability" of forest practices. I argue that:

1. The general principle of managing ecosystems to conserve their natural character is applicable wherever society considers it to be desirable.
2. Practices designed to conserve particular ecological characteristics of forests are applicable, in a general sense, in other forests which share those characteristics. The particular practices suitable for conserving those characteristics will be most similar between ecologically similar regions.
3. The detailed prescription of how to conserve those characteristics must be site and stand-specific.

UNIVERSAL ECOLOGICAL CHARACTERISTICS

It is useful to distinguish among ecological characteristics that are universal (occur in all, or almost all, forests), those that show regional variation, and those that vary locally. Beyond the fact that they all contain trees, there are probably very few truly universal characteristics of forests. However, some of the ecological characteristics that New Forestry practices seek to conserve are virtually universal, for our purposes. For example, standing dead trees and cavity-nesting birds occur in most forest regions of the world, and certainly in all regions of British Columbia (Short 1982). Of course, the species, abundance, temporal dynamics, and spatial distribution of these elements all show considerable regional and local variation.

REGIONAL ECOLOGY

The Biogeoclimatic Ecosystem Classification (BEC) system (Pojar *et al.* 1987) provides a basis for applying ecologically appropriate management practices to the diverse range of forest ecosystems found in British Columbia. This system analyses both vegetation and environmental factors (climate and soils). At the regional level, biogeoclimatic zones, subzones and variants are recognized on the basis of climatic climax vegetation. Within this regional framework there is also a system of site classification.

Similar systems of land classification are used in the United States. In both British Columbia, Washington, and Oregon, the word "zone" has essentially the same meaning: a climatic region defined by the presence or expectation of a characteristic plant community occurring on zonal sites. Although no unified ecological classification exists to apply to both British Columbia and areas of the United States, some crude but useful comparisons can be made using existing systems.

Much of the research behind New Forestry and the development of New Forestry practices has been centred on forests of the Western Hemlock Zone (defined in Franklin and Dyrness 1973). This zone, which is closely analogous to the Coastal Western Hemlock (CWH) Zone of the BEC system,¹ extends along the coast from northern California to Alaska. It contains a tremendous diversity of environments. Although western hemlock is the expected climax species of this zone, throughout much of Oregon, Washington, and southern British Columbia, Douglas-fir is a long-lived sub-climax species which dominates many forests. The presence of Douglas-fir contributes to the special characteristics of Westside old-growth (Franklin *et al.* 1981). Presumably, the greatest resemblance to old-growth forests of the Westside would occur in those forests of the province in the CWH Biogeoclimatic Zone within the range of Douglas-fir (Figure 13). Given the important role of summer drought in the ecology of Westside Douglas-fir forests, the similarities would be greatest in the drier sub-zones, and on the drier sites. For example, the old-growth stands in McMillan Park, on the east side of Vancouver Island, show strong similarities to those of west central Oregon.

There may also be important ecological differences between Westside Douglas-fir forests and those in British Columbia. For example, coastal British Columbia has soils derived predominantly from glacial materials and often rather shallow; western Oregon has many older, weathered soils, some very coarse-textured and deep. These factors can influence the processes of nutrient cycling and the role of soil moisture in forest ecosystems (H. Kimmins, University of British Columbia, personal communication). The similarity to Westside forests diminishes in British Columbia as one moves inland towards more continental climates, or north towards cooler and wetter climates.

Strong similarities also exist between the Sitka Spruce Zone (Franklin and Dyrness 1973), occupying a tapering coastal fringe from the Olympic Peninsula to central Oregon, and the maritime and hypermaritime sub-zones of the CWH. These subzones occur on western Vancouver Island, the mainland coast north of Vancouver Island, and the Queen Charlotte Islands. This region of similarity extends north to the coastal forests of southeast Alaska. Despite the differences in species composition between the Westside and southeast Alaska, there appears to be a strong similarity in the structure of old-growth stands between these two regions (Brady and Hanley 1984).

¹ Krajina V. J. 1978. Vegetation of Western North America. Unpublished report.



FIGURE 13. Old-growth western hemlock/Douglas-fir/western redcedar forest, Nimpkish Valley, Vancouver Island. Some old-growth forests in British Columbia are structurally very similar to those of Oregon and Washington for which New Forestry practices were designed.

A third area of similarity is between forests on both sides of the border east of the Cascades. The Ponderosa Pine, Interior Douglas-fir, Interior Cedar, Hemlock, Montane Spruce, and Englemann Spruce Sub-alpine Fir Biogeoclimatic zones all extend some distance into the United States. Within some of these regions, opportunities for uneven-age silviculture are greater than in the CWH.

These areas of ecological similarity should not be interpreted to mean that management prescriptions can be simply transported from one region to another. Rather, they indicate an opportunity for forest researchers and managers in this province to benefit from the experiences of the Americans, and vice-versa. They also indicate the areas between which practices, in the general sense, are most transportable.

SITE-SPECIFIC ECOLOGICAL CONDITIONS

Many of the ecological features that influence forest management prescriptions are variable between sites within a biogeoclimatic subzone. For this reason, the Site Series (Pojar *et al.* 1987) is considered the most appropriate categorical level of ecosystem interpretation for management purposes. The principle of "ecological equivalence" (Pojar *et al.* 1987) must be applied in determining where prescriptions developed on one site can be expected to succeed elsewhere.

STAND CONDITIONS

Stand conditions must also be considered in developing management prescriptions. For example, if green tree retention were proposed, factors to be evaluated would include logistic, economic, and safety concerns, the wind-firmness of the proposed leave trees, and the presence or absence of dwarf mistletoe, which could be transmitted to regeneration from overstory trees.

WILDLIFE RESOURCES

Many New Forestry practices are designed to improve the wildlife habitat quality of managed forests. Therefore, it is useful to compare the wildlife resources of the Westside with those of British Columbia, to help assess the applicability of New Forestry practices in this province.

British Columbia and the Pacific Northwest are both rich in wildlife species. Counting native species only, Washington and Oregon have 230 bird and 134 mammal species; while British Columbia has 282 bird and 102 mammal species (Bunnell 1990; Bunnell and Kremsater 1990). There is a considerable overlap in species between the two regions, although British Columbia has some additional significant species, such as grizzly bear and wolverine, and has more large predator/prey systems intact.

Timber resource comparison

As with ecological characteristics, there are important differences and similarities in the timber resource between British Columbia and Westside forests.

LANDSCAPE PATTERNS OF HARVESTING

The predominant use of dispersed patch clearcutting has led to a highly fragmented "checkerboard" forest landscape in Westside old-growth. In coastal British Columbia, the typical pattern has been of larger clearcuts, frequently progressing up a drainage with few uncut areas left behind (Figure 14). This difference in logging history between the two regions means that landscape-level prescriptions from the Pacific Northwest will not necessarily be appropriate for the situation in British Columbia. Nevertheless, loss and fragmentation of habitat is a concern in both environments, so the more general principles of landscape ecology are relevant to all of the province. Also, dispersed patch clear-cutting has been extensively used in the interior of British Columbia, creating a situation more directly comparable to the Westside.

ECONOMIC OPERABILITY

It is beyond the scope of this report to evaluate the economic viability of specific New Forestry practices. However, it should be noted that much of the old-growth timber in Washington and Oregon is valuable and very profitable to log. The same is true of some of British Columbia's forests, although other areas are presently economically marginal.



FIGURE 14. Progressive clearcutting, Harrison Valley, British Columbia.

TIMBER SUPPLY

Coastal British Columbia and the Westside have a similar age-class gap in their overall timber supply. In both cases, most timber harvested is predicted to come from old-growth for the next several decades, with timber shortages occurring in some areas. After that time, timber yields from second-growth plantations are predicted to increase. This means that for both regions, the next few decades will be critical in determining the long-term mix of plantations and reserved old-growth in their forest landscapes.

Conclusions

Both British Columbia and the United States prescribe a multiple-use approach to forest management. In both cases, protection of biodiversity is a high priority, although there are strong and sometimes conflicting desires for ecological and economic forest values in both societies.

The greatest ecological similarity between Westside and British Columbia forests occurs in the drier CWH subzones, but no ecological equivalence between British Columbia and Westside forests has been established. Both British Columbia and the Westside have a similar wildlife resource, notable for its diversity and richness.

Some New Forestry practices, such as managing snags for cavity-nesting birds, are almost universally applicable to British Columbia. Other practices, such as managing down logs for site productivity reasons, are probably widely applicable but with more variation. In all cases, management prescriptions must consider region-, site-, and stand-specific factors.

Scientific Basis of New Forestry Practices

This section of the report addresses the question, "What is the scientific basis for accepting New Forestry practices?" For better clarity, I have broken this question down into two parts. The first part examines the science behind New Forestry practices; the second part examines the general relationship between scientific evidence and management practice.

Scientific evidence

Given the forest ecosystems of the Westside, what is the evidence that specific New Forestry practices will meet the forest management objectives of the public forest lands in that region? With some variation, the science relating to specific ecological elements (features or processes) of Westside old-growth Douglas-fir forests is good. That is to say, it is based on several decades of studies, many published in respected peer-reviewed scientific journals. Some of these elements have been studied in a broad range of forest types, while others have been studied only in relation to Westside Douglas-fir forests.

However, the extent to which these processes or features can be perpetuated or duplicated in managed forests is a hypothesis still being tested. Many of the practices address multiple objectives. The evidence that some of these objectives will be met is very convincing, but for others it is highly conjectural.

I have chosen three main ecological elements of New Forestry to cover, which I believe represent the subject as a whole. Rather than review each topic in depth here, I will refer to other (and better qualified) authors who have done so, and summarize their conclusions.

Snags and wildlife trees

The use of snags and wildlife trees by birds is very well documented over a broad geographic range. For example, the chapter on snags in a wildlife management handbook (Neitro *et al.* 1985) cited 129 references relating to wildlife use of snags. One bibliography on cavity-nesting birds contained 1,713 references (Fischer and McLelland 1983). Snags and snag-dependent wildlife occur in all North American forest regions (Short 1982). Predictions about the availability or functioning of these features in managed stands are less well supported, but are not entirely hypothetical. For example, Dickson *et al.* (1983) found that snag retention significantly increased bird use of a clearcut area. Zarnowitz and Manuwal (1985) found that density of cavity-nesting birds increased with snag density for all successional stages.

Additionally, indirect evidence can be gleaned from the study of naturally regenerated younger stands (Hansen 1990). For example, Franklin (1990) suggests that suitable habitat for spotted owls might develop in stands harvested with green tree retention and managed on 120-year rotations. Such a statement, although essentially speculative, is given some credibility by the existence on the Olympic Peninsula of 70-year-old stands resulting from a wind storm which left large trees, snags, and coarse woody debris. Some of these stands do provide Spotted Owl habitat (J. Springer, Dept. of Natural Resources, State of Washington, personal communication).

Down logs on land

Down logs may have many functions in forests (Harmon *et al.* 1986). I discuss here the scientific evidence concerning just three of these: as substrate for plants; as animal habitat (vertebrates only); and as an element in nutrient cycles, carbon budgets and site productivity.

PLANT SUBSTRATE

The phenomenon of "nurse logs" is well documented. Harmon *et al.* (1986) cited 26 references from a wide geographic range, reporting plants growing on down logs. However, the importance of nurse logs is less well known. Harmon *et al.* (1986) cited 5 studies (4 from western coniferous forests) which found that the proportion of seedlings growing on logs was higher than the proportion of ground covered by logs, indicating seedling "preference" for logs as seedbed.

The reasons why down logs provide a superior substrate are not well studied. Large rotten logs retain a high moisture content, even through protracted summer drought in warm climates (Maser and Trappe 1984). This may be an important factor for revegetation, especially in dry environments. Harvey *et al.* (1978, 1979) found a higher level of mycorrhizal activity in logs than in surrounding soil during dry periods, suggesting that down logs may benefit seedlings even if they are not directly rooted in the rotten wood. Other researchers speculate that down logs may benefit seedlings by providing a seedbed free of bryophyte competitors, raised above snowpack levels, and less accessible to browsing animals.

ANIMAL HABITAT

A wide range of animals use down logs, including bears, rodents, and salamanders (Bartels *et al.* 1985). Maser and Trappe (1984) cite 16 references to the role of down logs as habitat for vertebrates. However, the habitat value of down logs has been studied in detail for only a few mammal species (Maser *et al.* 1978) and none of the amphibians (Harmon *et al.* 1986).

NUTRIENT CYCLING, CARBON BUDGETS, AND SITE PRODUCTIVITY

Harmon *et al.* (1986) found eight sites on which the role of down logs in nutrient cycling had been studied (Table 1). These studies show considerable regional variation in the nutrient cycling role of down logs. An interesting comparison can be made between two studies from the Pacific Northwest: one of an old-growth Douglas-fir stand in western Oregon (Sollins *et al.* 1980), and the other of a 120-year-old western hemlock stand in coastal Oregon. For the Douglas-fir stand, coarse woody debris accounted for 17% of total organic matter and contained 4% of total nitrogen; for the hemlock stand, coarse woody debris accounted for 10% of the organic matter and 0.4% of the nitrogen.

The importance of nutrient input to the forest floor via coarse woody debris may also be variable. At Hubbard Brook, Vermont, coarse woody debris accounted for 3% of nitrogen input to the forest floor, while at H.J. Andrews Forest in Oregon, it accounted for 16% (Harmon *et al.* 1986).

The accuracy of present methods for assessing low-level N-fixation is questionable (Harmon *et al.* 1986). Asymbiotic N-fixation is known to occur in down logs, and it contributes approximately 1 kg/ha per year throughout a range of North American forests. This would constitute about 20% of total external inputs for an old-growth Douglas-fir forest (Sollins *et al.* 1980), but less than 5% for an eastern hardwood forest in a region of high nitrogen input from precipitation (Likens *et al.* 1977).

The effect of down logs on long-term site productivity was simulated by Harmon *et al.* (1986) using FORCYTE 10 (Kimmins and Scoular 1979, 1981), for a 60-year old western hemlock stand in coastal Oregon. Site productivity was modelled for seventeen 30-year rotations, and for six 90-year rotations, with and without removal of the old-growth coarse woody debris left over from the previous stand. For both rotation lengths, simulated yield was initially higher with coarse woody debris removed, but fell to about 5% less than with it in subsequent rotations (Figure 15). The researchers note that the site used for this simulation was very rich in nitrogen, and that the effect of coarse woody debris removal could be greater on less fertile sites.

The results of the above simulation can be explained by the phenomenon of immobilization. Vitousek and Matson (1985) discuss the loss of nitrogen from intensively managed coniferous forests following clearcutting. They note that organic residues including coarse woody debris provide a carbon-rich substrate that provides a substrate for immobilization of the increased nitrogen which becomes available after harvesting. They suggest that removal of such organic residues will increase the potential for nitrogen loss following harvesting. Coarse woody debris is a buffer to nitrogen cycling, acting initially as a sink, but ultimately as a source.

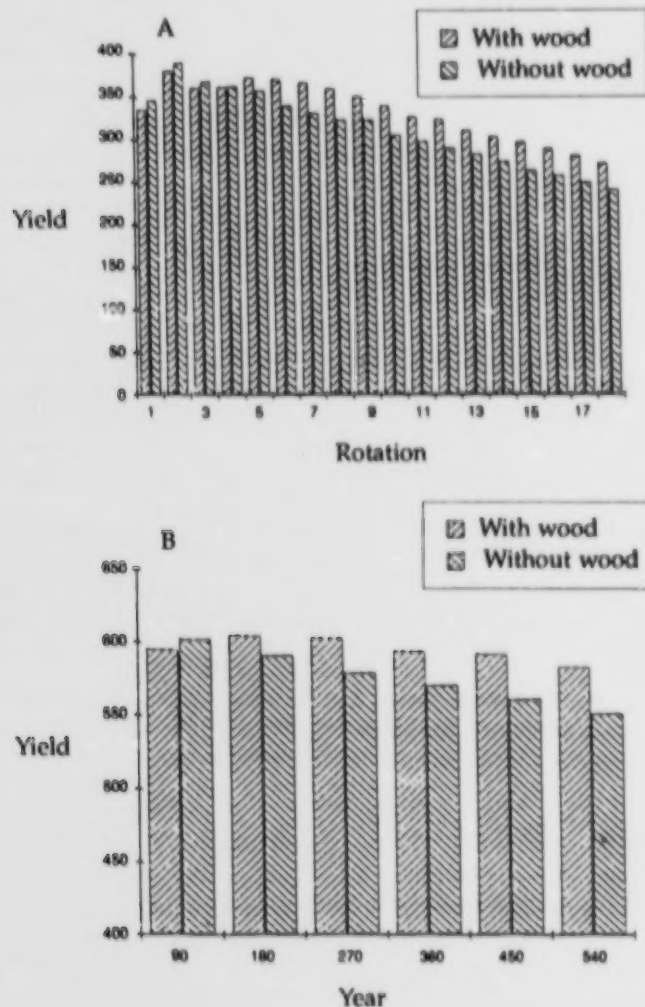


FIGURE 15. Predicted effect of coarse woody debris removal on yield from a western hemlock plantation in western Oregon. Rotations are (A) 30 years and (B) 90 years. Based on FORCYTE-10 model. Source: Harmon *et al.* 1986.

Landscape level considerations

The theoretical foundations for the landscape-level practices of New Forestry are found in the fields of landscape ecology, conservation biology, and the "pre-New Forestry" body of theory and practice related to forest management and regulation.

Numerous concerns have been proposed for consideration in the management of forest landscapes, including insect pests, diseases, wildfire, windthrow (Perry 1988), and hydrology (Grant 1990). According to DeBell (1990): "At present, specific prescriptions to achieve these landscape-level goals are informed guesses and hypotheses, rather than established procedures."

However, landscape-level practice to date has concentrated on questions of wildlife habitat. With the continued fragmentation and conversion of old-growth to managed forest on the Westside, the predominant wildlife and habitat concern has shifted away from game animals towards old-growth associated or dependent species.

The theory of island biogeography (MacArthur and Wilson 1967) predicts that the number of species found on islands is a function of area (species/area relation), and reflects a balance of extinctions and immigrations from the mainland continent (equilibrium theory). To the extent that isolated patches of old-growth forest habitat are similar to true islands, island biogeography should provide a theoretical foundation for the management of old-growth dependent species on the Westside.

In a comprehensive treatment of the subject (citing 285 references), Harris (1984) noted several weaknesses of the theory of island biogeography when applied to the problem of maintaining biodiversity in Westside forests. These include the fact that for some species, old-growth patches are not analogous to islands; the lack of a "continent" to provide a source of immigrant species; and the fact that number of species *per se* is not the objective. However, he concludes that a useful strategy for maintaining Westside biodiversity can be devised despite these weaknesses. Island biogeography implies that habitat reserves should be as well-connected as possible. Bunnell and Kremsater (1990) note that this may not be desirable for all conditions, because it leaves populations vulnerable to rare large-scale catastrophes or epidemic diseases. They conclude that integrated management of timber and biodiversity can be very successful at the stand level, but that "our major task is to learn how to distribute our management practices through time and space."

Summary

- We know that many wildlife species depend on snags for habitat. In many cases we have detailed information on a species basis. We also know that practices can be designed to maintain at least some of the habitat value of snags in managed forests.
- We know that the presence of down logs may influence seedling establishment and survival. We are less sure why and when this is important. This function may be most critical in dry environments.
- We know that down logs are important habitat elements for some small mammals and amphibians. We do not know the habitat value of down logs for many other animals, nor do we know to what extent the habitat value of down logs can be maintained in managed forests.
- We know that down logs play a variable role in forest nutrient cycles. This function is perhaps more important on less fertile sites. Removal of coarse woody debris may reduce long-term productivity in some cases.
- We know that successful integrated management requires a landscape perspective. We have some useful theoretical tools, but developing a practice of forest landscape management remains one of our most significant challenges.

Conclusions

The statement that New Forestry is not based on good science is mostly untrue. The statement that New Forestry practices are hypothetical and untested is mostly true.

Scientific Evidence and Management Practice

What kind of scientific evidence is required for acceptance of a given forest management practice?

It has been suggested that New Forestry practices are being implemented on a wide scale before being properly tested (Atkinson 1990). In fact, the same is largely true of all modern forestry practices, for reasons related to a predictable pattern of development in forestry science and practice. Kimmins (1987) suggests that forestry typically evolves through six major stages:

1. Unregulated exploitation of forests with no thought for depletion or conservation.
2. Perception of real or threatened future shortages of forest resources.
3. Exploitation of undepleted forests at more remote locations (stages 1 and 2 repeated); and/or
4. Institution of simple, non-ecological regulations concerning future forest cutting and management.
5. Realization that simple administrative dictates cannot ensure adequate future supplies of forest resources.
6. Initiation of a continuing development of ecologically based forest resource conservation and management practices, usually accompanied by increasing success in the conservation and production of forest crops.

Note that stage 6, the development of scientific forestry, only occurs after a considerable period of exploitation and the perception of shortages. In a practical social setting, scientific forestry does not begin to evolve until society has already developed an exploitation infrastructure and an ongoing demand for forest resources. Therefore, social forces dictate that scientific forestry must be developed while forest harvesting continues.

A good example of this sequence can be seen in the development of regeneration technology on the Westside and in British Columbia. Atkinson (1990) notes that in the early post-war period, survival of artificial regeneration was typically very poor, and that the present methods of reforestation were developed over several decades of research. Notice, however, that this development took place over a period of rising harvest levels. Regeneration had to be accomplished somehow. Throughout much of this period, artificial regeneration methods were derived from untested scientific hypotheses, not from established management practice. In British Columbia, artificial regeneration methods still represent essentially a hypothesis: we plant millions of container seedlings every year even though we have yet to harvest a container plantation. Given the very long time needed for forest crops to mature, and the relative mutability of forest management goals, foresters rarely have the luxury of using well-proven methods. They must rely on scientific evidence to predict which practices will work best (Smith 1986).

Recognition of this relation between science and management has led to the philosophy of "Adaptive Management." Walters (1986) says, "This approach begins with the central tenet that management involves a continual learning process that cannot conveniently be separated into functions like 'research' and 'ongoing regulatory activities', and probably never converges to a blissful equilibrium involving full knowledge and optimum productivity." In most cases where New Forestry practices are implemented, it is with an explicit adaptive management philosophy. In other words, the forest managers recognize that any management activity constitutes an experiment — an ecological perturbation with unknown effects. That experiment can only yield useful information if it is controlled and the results are monitored.

Conclusions

Social changes and economic development cause forestry objectives to change. This in turn requires changes in forestry practices. Because forests operate on longer time scales than humans, foresters seldom have the option of fully testing new practices before implementation. It is customary for foresters to implement new practices on the basis of scientific prediction.

V DISCUSSION

Comments Received

On my field trip to Washington and Oregon, and in some of my telephone interviews, I received comments from people interested in New Forestry which I think are worth mentioning.

Several people commented that my subject was too big to be covered in the time I had available, because New Forestry affects so many aspects of forest practice. If foresters in British Columbia decide to implement some of the practices described in this report, they may want to seek more detailed information.

The comment I heard innumerable times was that the selection of forest practices depends on the owner's objectives. Nobody tried to tell me that New Forestry practices were "the right way" to do things, but many believed that they were the best way, given the objectives which are emerging in Westside forests.

Many employees of the U.S. Forest Service are unhappy with the public image of their agency. They are keenly aware that they have lost the confidence of a large segment of the public. Some of them feel they have an impossible task: that there is no way they can make the forests continue to yield timber, recreation and ecological values at the levels expected. There is some sense of opportunity lost, because the critical questions about the future of the forests were not addressed in time. Many Forest Service employees now fear that their discretionary role as forest managers will be revoked, and replaced by prescriptive legislation, dictating forest practices. They expressed the hope that forest managers in British Columbia will "learn from their mistakes" and begin to manage for a wider range of forest values, before it becomes too late.

Above all, I got a very strong impression of their dedication, as public servants, to managing the publicly owned forests for the general public benefit, and their commitment to the importance of public participation in all phases of forest use planning.

New Forestry: What It Can and Can't Do

The practices described in this report were designed to address a broader range of objectives than those of conventional forestry. However, New Forestry is not a panacea. What New Forestry can do, if properly applied, is to help us keep more biological diversity, maintain long-term productivity, and protect the ecological resilience of the landscapes which we choose to manage for timber production.

Most observers do not consider the visual impact of light or medium conifer retention logging to be an improvement over clearcutting (Atkinson 1990; Taylor 1990). However, New Forestry practices may help to lessen the visual impact of logging on some landscapes. For example, an area logged with heavy conifer retention will begin to look "natural," at least from a distance, sooner than a clearcut.

What New Forestry cannot do is magically resolve the major land use issue that exists around British Columbia's forests, especially the coastal old growth. New Forestry practices are intended to chart a middle course between total preservation, and the loss of ecological values that conventional forestry entails. They are not intended to be a substitute for all forest preservation. New Forestry explicitly recognizes the need for reserved areas within the forest landscape (Franklin 1990).

Many reasons exist for excluding timber management from some forest areas, such as the need for ecological reserves, roadless wilderness areas for recreation, spiritual, and existence values, and native land claim settlements. The practices described in this report do not address these issues.

Other Analyses of New Forestry

Few analyses of New Forestry have been made which attempt to identify its weaknesses or faults. DeBell (1990) finds the philosophy of New Forestry valid, but notes the weakness of the "naturalistic idealogy" behind some New Forestry practices: "This influence led to one silvicultural plan that included as goal statements such things as 'manage forests for natural functions' and 'emulate natural processes'. Such goals obviously lack clarity; how does one monitor subsequent developments to see if goals are met?"

The advantages of having well defined goals are indisputable. However, given our incomplete understanding of ecosystem function, a certain amount of "emulating natural processes" may be excusable if we intend to keep all the "cogs and wheels." In other words, we might choose to manage for some characteristics that we find in natural forests, not because we know we need them, but because we don't know that we don't need them.

DeBell (1990) also notes the hypothetical nature of many New Forestry practices, and he urges that the useful tools of conventional forestry practice not be belittled or abandoned in the rush to embrace the new. He concludes that the practices of New Forestry are a valuable contribution toward the development of multi-purpose forestry.

Many of the most commonly expressed criticisms of New Forestry are stated by Atkinson (1990). Many people who have reservations about New Forestry, especially those from the timber industry, refer to this paper as expressing their concerns. I have therefore included its entire text in Appendix 5.

Many of the points raised by Atkinson (1990) concern questions of forest *policy* rather than *practice*, and are thus outside the main subject of this report. Essentially, he argues that New Forestry shifts the emphasis in forest management too far away from timber values towards ecological and non-timber values. This is (one hopes) a question to be decided through public participation and the political process. Atkinson (1990) makes the important point that the public should be fully informed of the economic implications of forest practices and policies. Some of Atkinson's (1990) technical comments on New Forestry are referred to in appropriate areas of this report.

Atkinson (1990) lists "Multiple entries for harvest (come back every ten years and log it again)" as a characteristic New Forestry practice. As discussed earlier, this practice is not being suggested for widespread application in Westside Douglas-fir as part of New Forestry (DeBell 1989; Franklin 1990).

Other critics of New Forestry charge that it does too little to protect ecological values. One critic calls New Forestry "battered-up clear cutting," and advocates uneven-age silviculture (N. Fritz, Forest Reform Network, quoted in Foss 1990).

VI RECOMMENDATIONS

Defining Goals

A theme I have developed throughout this report is that forestry practices are derived from objectives. New Forestry is based on the premise that conventional forestry practices sacrifice many of the ecological elements of the forest, and it seeks to conserve them by developing alternative practices. We cannot judge how applicable those practices are to British Columbia until we decide how highly we value those ecological elements.

I have shown some evidence that British Columbians value these elements highly. On the other hand, practices designed to protect all the ecological elements of the forest may yield less timber or revenue than would intensive plantation forestry. There is evidence that British Columbians also value the economic benefits of timber production. Where do we strike the balance? The answer need not be the same for all pieces of land or all regions of the province. Clearly, what is needed is an ongoing public involvement in the formulation of local and province-wide forest management goals.

Research

Assuming that we may want to manage some part of our forest lands for more ecological values, what information are we lacking?

ECOSYSTEM FUNCTION

Researchers in Washington and Oregon have concluded that some structural characteristics of old-growth forests exert a strong influence on composition and function (Franklin *et al.* 1981). Since these characteristics occur in many British Columbia forests also, it would be reasonable to begin testing the

relations between structure, function, and composition more thoroughly in British Columbia forests. This work must be done on an ecosystem-specific basis.

We have little information on the role of coarse woody debris in site productivity and regeneration for most British Columbia ecosystems. Scientists speculate that it may be important in some ecosystems but much less so in others (H. Kimmins and R. Carter, University of British Columbia, personal communication). Future research may indicate that minimum residue guidelines are desirable in some areas, which might require revision of existing utilisation standards. In such a case, the ecological benefits of coarse wood debris would have to be balanced against the economic benefits (or costs) of close utilisation and fuel management objectives. For other areas, ecological considerations may be compatible with current, or even closer, utilization standards.

We have already learned that the distinctive canopy structure of old growth is important in some cases (Jones and Bunnell 1984). Perhaps there are other important functions still to discover.

NATURAL DISTURBANCE AND RECOVERY

Studying how forests recover from natural disturbances has yielded valuable results for researchers in the United States (Franklin 1990). We have relatively little ecosystem-specific data on the natural disturbance regimes that influenced our old-growth forests. These should be studied at the stand and landscape levels. In general, we have more information on the stand-destroying role of events such as wildfire, than on the role of processes that replace individual or groups of trees within stands. These gap processes may be an important mechanism for perpetuating the forest in some British Columbia environments (e.g., Lertzman 1988; Hopwood 1990). The forest structure created by such processes is an important habitat feature for a wide range of species (Bunnell and Kremsater 1990).

SILVICULTURAL METHODS

Ecosystem research, as described above, should lead to the development of ecosystem-specific New Forestry silvicultural methods as one of its end-products. Because such methods must be applicable in a practical and economic sense, this work is probably best conducted by research/management partnerships.

Considerable research has already been done on innovative silviculture to conserve ecological values in co-ordination with timber management. We have some success stories in managing for featured species (Armleder *et al.* 1986; Nyberg *et al.* 1986). Managing for whole ecological communities carries the concept a step further. Work of this kind should be encouraged.

Some silvicultural systems that may be prescribed under New Forestry are similar to systems already used in British Columbia. For example, seed tree cutting has been used in the Arrow District of southeastern British Columbia, leaving western larch seed trees on sites planted with lodgepole pine to promote a mixed species stand (R. Augustine, B.C. Ministry of Forests, personal communication). (Figure 16). Other examples include shelterwood cutting which is being done experimentally in the Fraser Canyon (R. Green, B.C. Ministry of Forests, personal communication) or in the University of British Columbia Research Forest (D. Munro, personal communication). These examples illustrate that some New Forestry practices would not be altogether new in parts of British Columbia, and could be implemented with existing skills, procedures and equipment.

International Co-operation

Given the similarity of forests in British Columbia and the Pacific Northwest, much could be gained by more international co-operation in forest research, particularly on some of the challenging large-scale problems such as the conservation of biodiversity and the effects of climate change on forests.

To facilitate the transfer of information and technology between the two regions, an exchange program could be developed for forest managers.



FIGURE 16. Seed tree harvest with western larch overstory, Arrow District, British Columbia.

Education

If there is to be a trend towards whole ecosystem management in British Columbia forestry, its success will depend in part on the ability of foresters and field workers to observe and interpret ecological conditions of the forest. Such skills develop with experience, but depend to some extent on a solid educational foundation. While it is true that foresters trained in British Columbia do study forest ecology, the emphasis is on those aspects of ecology related to timber production. For example, for a degree in Forest Resource Management at the University of British Columbia's Faculty of Forestry, one course in Silvics and Forest Ecology is required, but any study of Forest Wildlife Ecology is optional. British Columbia's educational institutions should evaluate the need for curriculum changes.

Adaptive Management

In some ways, it would be premature and impractical to begin large-scale implementation of New Forestry practices in British Columbia, given the weakness of our ecological knowledge base. Nevertheless, it must be argued that ignorance is a poor justification for preserving the status quo. This is essentially a question of risk management philosophy: Do we assume that what we don't know can't hurt us, or that it can? It would perhaps be wise to begin using practices that retain more of the structures we find in the natural forest. Through doing so, we will be able to learn more about the compositional and functional roles of those structures.

Our lack of detailed ecological information on many of the forests in British Columbia need not prevent us from adopting an ecosystem approach to forest management. Certainly, one does not need a Ph.D. in forest ecology to recognize a snag or a down log, or to note some basic stand structure features such as species mix or canopy heterogeneity. It would be fairly easy for foresters to note this kind of information while collecting

information for Pre-Harvest Silvicultural Prescriptions (PHSP's), and to incorporate measures to retain more of such features into their silvicultural prescriptions. This would be part of an "adaptive management" approach, one which could lead to rapid development of new knowledge and techniques.

Watershed Inventory and Planning

The essence of New Forestry at the landscape level is to plan forest activities over whole watersheds. In British Columbia, we are still in the position of entering new watersheds for timber development. This gives us the opportunity to identify ecologically sensitive areas, important habitat areas and corridors, and areas of visual sensitivity, as well as to develop a landscape-level plan to protect important values. Interdisciplinary landscape-level planning can do much to improve the effectiveness of our integrated resource management efforts.

Wildlife Trees and Snags

The evidence that conventional forest management destroys essential habitat for some of our bird fauna is indisputable. Foresters in the United States now routinely prescribe harvesting practices which conserve habitat for cavity-nesting birds. We are clearly overdue for a change in practice here in British Columbia.

The problem of safety is critical to this question. There are some lessons to be gained from the experience in Oregon, where the Forest Service apparently began requiring loggers to leave snags and trees which the safety authorities required them to fell. The loggers were thus unfairly caught in a "Catch-22" situation between two conflicting jurisdictions.

There is presently a wildlife tree committee working on this problem in British Columbia. Ideally, the process will involve loggers, Ministry of Forests and Ministry of Environment personnel, and the Worker's Compensation Board in developing safe and effective ways to preserve wildlife habitat in managed forests.

Habitat Reserve Areas

Although innovative silviculture can do much to maintain wildlife habitats in managed forests, some species appear to require old growth (Fenger and Harcombe 1989; Bunnell 1990). For such species, habitat reserves will be required. Given the present pace of conversion of old growth in British Columbia, little time should be lost in establishing such reserves.

Ecological Reserves

Much of the scientific background for New Forestry on the Westside came from studies of undisturbed old-growth forests. If we are to carry out any similar research programs in British Columbia, we need to ensure that representative samples of all our major forest ecosystems are reserved from logging or development. To permit landscape-level studies, such reserves will need to be larger than many of the ecological reserves that have been created in the past. Creation of a system of such reserves should be given a high priority.

VII REFERENCES

- Amaranthus, M.P. 1990. Rethinking the ecology and management of temperate forests: the living soil. *In* Proc. Symp. on Forests — Wild and Managed: Differences and Consequences. A.F. Pearson and D.A. Challenger (editors). Students for Forestry Awareness, Jan. 19-20, 1990, Univ. B.C., Vancouver, B.C. pp. 55-65.
- Armleder, H.M., R.J. Dawson, and R.N. Thomson. 1986. Handbook for timber and mule deer co-ordination on winter ranges in the Cariboo Forest Region. B.C. Min. For., Victoria, B.C. Land Manage. Handb. No. 13.
- Atkinson, W. 1990. Another view of New Forestry. Paper presented at Annual Meeting, Oreg. Soc. Am. For., Eugene, Oreg. May 4, 1990.
- Barteis, R., J.D. Bell, R.L. Knight, and G. Schaefer. 1985. Dead and down woody material. *In* Management of wildlife and fish habitats in forests of Oregon and Washington. E.R. Brown (editor). U.S. Gov. Printing Office, Washington, D.C. Pub. No. R6-F&WL-192-1985. pp. 171-186.
- Brady, W.W., and T.A. Hanley. 1984. The role of disturbance in old-growth forests: some theoretical implications. *In* Proc. Symp. on Fish and Wildlife Relationships in Old-Growth Forests. W.R. Meehan (editor). Juneau, Alaska. April 12-15, 1982. Am. Inst. Fish. Res. Biol., Washington, D.C.
- Brown, E.R., and A.B. Curtis. 1985. Introduction. *In* Management of wildlife and fish habitats in forests of Oregon and Washington. E.R. Brown (editor). U.S. Gov. Printing Office, Washington, D.C. Pub. No. R6-F&WL-192-1985. pp. 1-15.
- Bunnell, F.L. 1990. Biodiversity: what, where, why, and how. Paper presented to: Wildl. For. Symp. and Workshop, March 6-8, 1990. Prince George, B.C.
- Bunnell, F.L. and L. Kremsater. 1990. Sustaining wildlife in managed forests. *Northwest Environ. J.* 6:243-269.
- Caulfield, C. 1990. Reporter at large (The Pacific Forest). *The New Yorker*. May 14, 1990.
- Commission on Old-Growth Alternatives for Washington's Trust Lands. 1989. Submitted to Brian Boyle, Commissioner of Public Lands, Washington State. Olympia, Wash.
- DeBell, D. 1989. Alternative silvicultural systems — west: a perspective from the Douglas-fir Region. Paper presented at the National Silv. Workshop U.S. Dep. Agric. For. Serv., Petersburg Alaska, July 10-13, 1989.
- DeBell, D. 1990. Silvicultural practices and "new forestry". Paper presented at New Forestry in the 90's, Workshop sponsored by Coos Chapter, Soc. Am. For. and Southwest. Oreg. Comm. Coll. in Coos Bay, Oreg. April 19, 1990.
- Denison, W.C. 1979. *Lobaria oregana*, a nitrogen-fixing lichen in old-growth Douglas-fir forests. *In* Symbiotic Nitrogen Fixation in the Management of Temperate Forests. J.C. Gordon, C.T. Wheeler, and D.A. Perry (editors). Oreg. State Univ. For. Res. Lab., Corvallis, Oreg. pp. 266-275.
- Dickson, J.G., R.N. Conner, and J.H. Williamson. 1983. Snag retention increases bird use of a clear-cut. *J. Wildl. Manage.* 47:199-804.
- Enviroics Research Group Ltd. 1989. National survey of Canadian public opinion on forestry issues. Poll for For. Can.
- Eubanks, S. 1990. Applied concepts of ecosystem management: developing guidelines for coarse woody debris. *In* Maintaining the long-term productivity of Pacific northwest forest ecosystems. D.A. Perry, R. Meurisse, B. Thomas, R. Miller, J. Boyle, J. Means, C.R. Perry, and R.F. Powers (editors). Timber Press, Portland, Oreg. pp. 230-236.

- Everest, F.H., M.B. Armantrout, S. Keller, W. Parante, J. Sedell, T. Nickelson, J. Johnston, and G. Haugen. 1985. Salmonids. In *Management of wildlife and fish habitats in forests of Oregon and Washington*. E.R. Brown (editor). U.S. Gov. Printing Office, Washington, D.C. Pub. No. R6-F&WL-192-1985. pp. 199-230.
- Fenger, M. and A. Harcombe. 1989. A discussion paper on old-growth forests, biodiversity, and wildlife in British Columbia. Prepared by the Wildl. Br., B.C. Min. Environ., for the Invitational Workshop "Towards an Old-Growth Strategy." Nov. 3-5, 1989. Parksville, B.C.
- Fischer, W.C., and B.R. McLelland. 1983. A Cavity-nesting bird bibliography-including related titles on forest snags, fire, insects, disease, and decay. U.S. Dep. Agric. For. Serv., Intermount. For. Range Exp. Stat., Ogden, Utah. Gen. Tech. Rep. INT-140.
- Forman, R.T.T., and M. Godron. 1986. *Landscape Ecology*. John Wiley and Sons, New York, N.Y.
- Foss, T. 1990. New Forestry: A state of mind. *Inner Voice* 2 (1): 4-6.
- Franklin, J.F. 1990. Old-growth forests and the New Forestry. In *Proc. Symp. on Forests — Wild and Managed: Differences and Consequences*. A.F. Pearson and D.A. Challenger (editors). Students for Forestry Awareness, Jan. 19-20, 1990, Univ. B.C., Vancouver, B.C. pp. 1-20.
- Franklin, J.F., and C.T. Dyrness. 1973. *Natural vegetation of Oregon and Washington*. U.S. Dep. Agric. For. Serv., Pac. NW For. Range Exp. Stat., Portland, Ore. Gen. Tech. Rep. PNW-80. 417 p.
- Franklin, J.F., and R.H. Waring. 1980. Distinctive features of the northwestern coniferous forest: development, structure, and function. In *Forests: fresh perspectives from ecosystem analysis*. R.H. Waring (editor). *Proc. 40th Annu. Biol. Colloq.* 1979: 59-86. *Oreg. State Univ. Press*. Corvallis, Oreg.
- Franklin, J.F., K. Cormack, Jr., W. Denison, A. McKee, C. Maser, J. Sedell, F. Swanson, and G. Juday. 1981. Ecological characteristics of old-growth Douglas-fir forests. U.S. Dep. Agric. For. Serv., Pac. NW For. Range Exp. Stat., Portland, Ore. Gen. Tech. Rep. PNW-116. 48 p.
- Franklin, J.F., J.A. MacMahon, F.J. Swanson, and J.R. Sedell. 1985. Ecosystem responses to the eruption of Mount St. Helens. *National Geographic Res.* 1:198-216.
- Franklin, J.F., and R.T.T. Forman. 1987. Creating landscape patterns by forest cutting: ecological consequences and principles. *Landscape Ecology* 1 (1): 5-18.
- Franklin, J.F., D.A. Perry, T.D. Schowalter, M.E. Harmon, A. McKee, and T.A. Spies. 1989. Importance of ecological diversity in maintaining long-term site productivity. In *Maintaining the long-term productivity of Pacific northwest forest ecosystems*. D.A. Perry, R. Meurisse, B. Thomas, R. Miller, J. Boyle, J. Means, C.R. Perry, and R.F. Powers (editors). Timber Press, Portland, Ore. pp. 82-97.
- Grant, G. 1990. Hydrologic, geomorphic and aquatic habitat implications of old and new forestry. In *Proc. Symp. on Forests — Wild and Managed: Differences and Consequences*. A.F. Pearson and D.A. Challenger (editors) Students for Forestry Awareness, Jan. 19-20, 1990, Univ. B.C., Vancouver, B.C. pp. 35-54.
- Hansen, A. 1990. Managing species diversity on forest lands. In *Proc. Symp. on Forests — Wild and Managed: Differences and Consequences*. A.F. Pearson and D.A. Challenger (editors). Students for Forestry Awareness, Jan. 19-20, 1990, Univ. B.C., Vancouver, B.C. pp. 109-114.
- Harmon, M.E., J.F. Franklin, F.J. Swanson, P. Sollins, S.V. Gregory, J.D. Lattin, N.H. Anderson, S.P. Cline, N.G. Aumen, J.R. Sedell, G.W. Leinkaemper, K. Cromack, Jr., and K.W. Cummins. 1986. Ecology of coarse woody debris in temperate ecosystems. *Advances in Ecological Res.* 15:133-302.
- Harr, R.D. 1986. Effects of clear-cutting on rain-on-snow runoff in Western Oregon: a new look at old studies. *Water Resources Res.* 27(7):1095-1100.
- Harris, L.D. 1984. *The fragmented forest: island biogeography theory and the preservation of biotic diversity*. Univ. Chicago Press, Chicago, Ill.
- Harvey, A.E., M.F. Jurgenson, and M.J. Larsen. 1978. Seasonal distribution of *ectomycorrhizae* in a mature Douglas-fir/larch forest soil in western Montana. *For. Sci.* 24:203-208.

- Harvey, A.E., M.J. Larsen and M.F. Jurgenson. 1979. Comparative distribution of ectomycorrhizae in soils of three western Montana forest habitat types. *For. Sci.* 25:350-358.
- Hemstrom, M. 1990. New Forestry — how will it look on the landscape? In *Proc. Symp. on Forests — Wild and Managed: Differences and Consequences*. A.F. Pearson and D.A. Challenger (editors). Students for Forestry Awareness, Jan. 19–20, 1990, Univ. B.C., Vancouver, B.C. pp. 27–34.
- Hopwood, D. 1990. Shade-tolerance of Douglas-fir in the Coastal Douglas-fir Salal Site Series. B.Sc. thesis. Univ. B.C., Fac. For., Vancouver, B.C.
- Isaac, L. 1956. Place of partial cutting in old-growth stands of the Douglas-fir region. U.S. Dep. Agric. For. Serv., Pac. NW For. Range Exp. Stat., Portland, Oreg. Res. Pap. PNW-16.18. 48 p.
- Jones, G. and F.L. Bunnell. 1984. Response of black-tailed deer to winters of different severity on northern Vancouver Island. In *Fish and Wildlife Relationships in Old-Growth Forests*. W.R. Meehan, T.R. Merrell, Jr., and T.A. Hanley, (editors). Am. Inst. Fish. Res. Biol., Morehead City, NC. pp. 385–390.
- Kimmins, J.P. 1977. Evaluation of the consequences for future tree productivity of the loss of nutrients in whole-tree harvesting. *For. Ecol. Manage.* 1 (1977):169-183.
- Kimmins, J.P. 1987. *Forest ecology*. MacMillan Publishing Co., New York, N.Y.
- Kimmins, J.P. 1990. Designing disturbance in the B.C. forest landscape: the prediction of ecological rotations. In *Proc. Symp. on Forests — Wild and Managed: Differences and Consequences*. A.F. Pearson and D.A. Challenger (editors). Students for Forestry Awareness, Jan. 19–20, 1990, Univ. B.C., Vancouver, B.C. pp. 177–192.
- Kimmins, J.P., and K.Scoullar. 1979. FORCYTE: a computer simulation approach to evaluating the effect of whole-tree harvesting on the nutrient budget in Northwest forests. In *Proc. Conf. on Forest Fertilization*. S.P. Gessel, R.M. Kenady, and W.A. Atkinson (editors). Inst. For. Resources Contrib. No. 40. Univ. of Wash., Seattle, Wash. pp. 266–273.
- Kimmins, J.P., and K.Scoullar. 1981. FORCYTE-10. In *Proc. 3rd Bioenergy R&D Seminar*. Nat. Res. Council Can., Ottawa, Ont.
- Leopold, A. 1966. *A Sand County Almanac with essays on conservation from Round River*. Oxford Univ. Press., New York, N.Y. 269 p.
- Lertzman, K. 1988. Gap-phase community dynamics in a sub-alpine old-growth forest. Ph.D. thesis, Univ. B.C., Vancouver, B.C.
- Lertzman, K. 1990. What's new about New Forestry: replacing arbocentrism in forest management. *For. Planning Can.* 6(3):5-6.
- Likens, G.E., F.H. Bormann, R.S. Pierce, J.S. Eaton, and N.M. Johnson. 1977. In *Biogeochemistry of a forested ecosystem*. Springer-Verlag, New York, N.Y.
- Maser, C., and J. Trappe. (editors). 1984. The seen and unseen world of the fallen tree. U.S. Dep. Agric. For. Serv., Pac. NW For. Range Exp. Stat., Portland, Oreg. Gen. Tech. Rep. PNW-164. 56 p.
- Maser, C., J. Trappe, and R. Nussbaum. 1978. Fungal-small mammal interrelationships with emphasis on Oregon coniferous forests. *Ecology*. 59:799-809.
- Neitro, W.A., V.W. Binkely, S.P. Cline, R.W. Mannan, B.G. Marcot, D. Taylor, and F.F. Wagner. 1985. Snags. In *Management of wildlife and fish habitats in forests of Oregon and Washington*. E.R. Brown (editor). U.S. Gov. Printing Office, Washington, D.C. Pub. No. R6-F&WL-192-1985. pp. 129–170.
- Norse, E.A. 1990. *Ancient forests of the Pacific Northwest*. The Wilderness Society. Island Press, Washington, D.C. 327 p.
- Nyberg, J.B., F.L. Bunnell, D.W. Janz, and R.M. Ellis. 1986. Managing young forests as black-tailed deer winter range. B.C. Min. For., Victoria, B.C. Land Manage. Rep. No. 37. 49 p.
- Old-Growth Definition Task Group. 1986. Interim definitions for old-growth Douglas-fir and mixed-conifer forests in the Pacific Northwest and California. U.S. Dep. Agric. For. Serv., Pac. NW For. Range Exp. Stat., Portland, Oreg. Gen. Tech. Rep. PNW-447.

- Olympic Experimental State Forest Draft Plan. 1990. Washington Department of Natural Resources, Olympic Region Office. Forks, Wash.
- Perry, D.A., R. Molina, and M.P. Amaranthus. 1987. Mycorrhizae, mycorrhizospheres, and reforestation: current knowledge and research needs. *Can. J. For. Res.* 17:929-940.
- Perry, D.A. 1987. The influence of site preparation on forest productivity. In *Proc. Cal. Conf. on Forest Nutrition*. R. Power and T. Robson (editors). U.S. Dep. Agric. For. Serv., Pac. SW For. Range Exp. Stat., Berkeley, Cal.
- Perry, D.A. 1988. Landscape pattern and forest pests. *The Northwest Environ. J.* 4:213-228.
- Perry, D.A., M.P. Amaranthus, J.G. Borchers, S.L. Borchers, and R.E. Brainerd. 1989. Bootstrapping in ecosystems. *BioScience* 39(4):230-237.
- Plochmann, R. 1989. The forests of Central Europe: a changing view. 1989 Starker Lectures, Oreg. State Univ., Coll. For., Corvallis, Oreg.
- Pojar, J., K. Klinka, and D.V. Meidinger. 1987. Biogeoclimatic ecosystem classification in British Columbia. *For. Ecol. Manage.* 22:119-154.
- Puleo, V. 1990. "Just Do It." In *Proc. Symp. on Forests — Wild and Managed: Differences and Consequences*. A.F. Pearson and D.A. Challenger (editors). Students for Forestry Awareness, Jan. 19-20, 1990, Univ. B.C., Vancouver, B.C. pp. 135-146.
- Roemer, H.L., J. Pojar, and K.R. Joy. 1988. Protected old-growth forests in coastal British Columbia. *Natural Areas Journal*. 8(3):146-159.
- Salwasser, H. 1990. New perspectives for managing the National Forest System: an introduction to the program. U.S. Dep. Agric. For. Serv., Misc. Pub.
- Schowalter, T. 1990. Differences and consequences for insects. In *Proc. Symp. on Forests — Wild and Managed: Differences and Consequences*. A.F. Pearson and D.A. Challenger (editors). Students for Forestry Awareness, Jan. 19-20, 1990, Univ. B.C., Vancouver, B.C. pp. 91-106.
- Sessions, J. 1989. Timber for Oregon's tomorrow: the 1989 update. Oreg. State Univ., For. Res. Lab., Corvallis, Oreg.
- Short, L.L. 1982. Woodpeckers of the World. Del. Museum of Natural History. Geenville, Del.
- Siskiyou National Forest. 1990. Draft environmental impact statement, Shasta Costa Timber Sales and Integrated Resources. U.S. Dep. Agric. For. Serv., Gold Beach, Oreg.
- Smith, D.M. 1986. The practice of silviculture. John Wiley and Sons, New York, N.Y. 527 p.
- Sollins, P., C.C. Grier, F.M. McCorison, K. Cromack, Jr., R. Fogel, and R.L. Fredrickson. 1980. The internal element cycles of an old-growth Douglas-fir ecosystem in western Oregon. *Ecol. Monogr.* 50:261-285.
- Soule, M.E., and D. Simberloff. 1986. What do genetics and ecology tell us about the design of nature reserves? *Biol. Conser.* 35:19-40.
- Swanson, F.J., G.W. Leinkaemper, and J.R. Sedell. 1976. History, physical effects, and management implications of large organic debris in western Oregon streams. U.S. Dep. Agric. For. Serv., Pac. NW For. Range Exp. Stat., Portland, Oreg. Gen. Tech Rep. PNW-56. 15 p.
- Taylor, R. 1990. New Forestry: a solution for loggers and owls? *Seattle Post-Intelligencer*, July 5, 1990.
- Thomas, J.W., C. Maser, and J.E. Rodiek. 1979. Edges. In *Wildlife habitats in managed forests: the Blue Mountains of Oregon and Washington*. Thomas, J.W. (technical editor). U.S. Dep. Agric. For. Serv. Washington, D.C. Agric. Handb. 553. pp. 48-59.
- U.S. Department of Agriculture. 1980. Policy on Fish and Wildlife. Washington, DC. Secretary's Memorandum no. 2019. Printed in: 45th N. Am. Wildl. Nat. Resource Conf. Trans. Wash., DC: Wildl. Manage. Inst.
- Vitousek, P.M., and P.A. Matson. 1985. Disturbance, nitrogen availability, and nitrogen losses in an intensively managed loblolly pine plantation. *Ecology* 66(4):1360-1376.

- Walters, C. 1986. *Adaptive Management of Renewable Resources*. MacMillan Publishing Co. New York, N.Y. 374 p.
- Wilcove, D.S., C.H. McLellan, and A. Dobson. 1986. Habitat fragmentation in the temperate zone. *In* *Conservation biology: the science of scarcity and diversity*. M.E.Soule (editor). Sinauer Assoc., Sunderland, Mass. pp. 237-256.
- Willamette National Forest. 1990. *Willamette National Forest Land and Resource Management Plan*. U.S.Dep. Agric. For. Serv., Eugene, Oreg.
- Wilson, E.O. 1988. The current state of biodiversity. *In* *Biodiversity*. E.O. Wilson (editor). National Academy Press, Washington, D.C. pp. 3-18.
- Witmer, G.W., M. Wisdom, E.P. Harshman, R.J. Anderson, C. Carey, M.P. Kuttel, I.D. Luman, J.A. Rochelle, R.W. Scharpf, and D. Smithey. 1985. Deer and elk. *In* *Management of wildlife and fish habitats in forests of Oregon and Washington*. E.R. Brown (editor). Pub. No. R6-F&WL-192-1985. U.S. Gov. Printing Office, Washington, D.C.
- World Commission on Environment and Development. 1987. *Our common future*. Oxford Univ. Press, Oxford.
- Zarnowitz, J.E., and D.A. Manuwal. 1985. The effects of forest management on cavity-nesting birds in northwestern Washington. *J. Wildl. Manage.* 49:255-263.

APPENDIX 1. Summary of Distinctive Characteristics of Westside Old-growth Douglas-fir Forests (Source: Franklin *et al.*, 1981)

The major ecological features of old-growth coniferous forests in the Douglas-fir region are reviewed. Special attention is given to characteristics that distinguish old-growth forests from managed and unmanaged (natural) young stands. The primary exemplary type is 350- to 750-year-old Douglas-fir — western hemlock forest typical of the western slopes of the Cascade Range, but other types and locales are discussed. Management techniques for maintenance of old-growth forests are also considered. Major conclusions are:

1. Approximately 175 to 250 years are required to develop old-growth forests under natural conditions in both Coast and Cascade Ranges. Development of old-growth is faster on good sites than on poor sites.
2. Few plant or animal species are solely confined to old-growth forests, although many species — including several vertebrates, saprophytic plants, and epiphytic lichens — find optimum habitats in such forests. Some organisms, however, may require old growth to maintain viable populations. Moreover, there are substantial differences in composition and relative abundance of species between young- and old-growth forests.
3. Gross productivity is maintained at high levels in most old-growth stands, but mortality generally balances growth. Thus, the merchantable board-foot volume tends to remain constant for several centuries or gradually decreases because the amount of defect increases. Total organic matter keeps increasing because of accumulated masses of dead tree boles, mostly as down logs.
4. Old-growth forests are highly retentive of nutrients; large amounts are incorporated into living and dead organic matter. Losses of limiting nutrients, such as nitrogen, are low.
5. Nitrogen-fixing epiphytes are abundant in old-growth trees, and bacterial nitrogen fixation appears to be common in the large woody debris characteristic of old-growth forests.
6. Small- to medium-size streams in old-growth forests depend mainly on forest litter for an energy base. These materials are invariably partially utilized before they are exported downstream.
7. The structure of old-growth forest is more heterogenous than that of young forests; coefficients of variation in tree sizes are greater, and understory patchiness is much higher than in young-growth stands.
8. Most of the distinctive features of old-growth forests can be related to four structural features: (1) large, live old-growth trees, (2) large snags, (3) large logs on land, and (4) large logs in streams. The structural features are related over time.
9. A large, old-growth Douglas-fir is individualistic and commonly has an irregularly arranged, large, coarse branch system, and often, a long crown. It is ideal habitat for specialized vertebrates, such as the red tree vole, northern spotted owl, and northern flying squirrel, as well as nitrogen-fixing lichens.
10. Large snags are valuable as habitat for a variety of vertebrates and invertebrates and as a future source of logs.
11. Logs on the forest floor are important habitats for small mammals, including species that disperse spores of mycorrhiza-forming fungi. They also are sites for substantial bacterial nitrogen fixation and are essential as seedbeds for some trees and shrubs.

12. Logs are critical to maintenance of physical and biological stability in headwater streams. Debris dams create stepped stream profiles that dissipate energy otherwise used for transporting sediment and lateral-cutting and downcutting of stream channels. Such dams, with their associated plunge pools and beds of trapped gravels and fine sediments, provide a range of habitats needed to maintain a full array of stream and stream-margin organisms. Logs are an important source of energy, and the bulk of the nitrogen supply of a stream comes from woody debris.
13. Foresters wishing to maintain or create ecosystems with old-growth characteristics can tie management schemes to maintenance or development of the four key structural components — large live, old-growth trees, large snags, and large logs on land and in streams.
14. Watersheds are probably best suited as management units for old-growth ecosystems. A small drainage usually has greater terrestrial habitat variability than occurs in a single stand, as well as a complete stream system. The size of a management unit will vary but probably should be at least 300 acres (120 hectares) to reduce effects of edges and susceptibility to damaging agents, such as wind, as well as to maintain viable populations of some birds and small mammals.
15. Buffer or leave strips along streams are also useful areas to manage as old-growth sites because woody debris is provided to the stream, and the riparian zone, a particularly rich and critical wildlife habitat, is protected. Such buffers, along with roadside strips of old-growth forest, also provide migration routes for wildlife between otherwise isolated patches of mature or old-growth forest.
16. Some ecological aspects of old-growth forests can be maintained by managing for individual attributes; for example, leaving scattered old-growth trees, rotten logs, or snags on cutover lands. The linked nature of these key structural components, as well as the requirements of some organisms for the total environment of an old-growth stand, makes management of entire stands a simpler approach to retention of such ecological features.

APPENDIX 2. Silvicultural Systems Used in New Forestry on the Westside (Source: *Shasta Costa Draft Environmental Impact Statement*, Siskiyou National Forest 1990)

TABLE OF CONTENTS

<u>Title</u>	<u>Page</u>
Introduction	49
Even-aged Systems	50
Light Conifer Retention - Clearcut	52
Moderate Conifer Retention - Seed Tree	54
Heavy Conifer Retention - Shelterwood System (Uniform)	56
Heavy Conifer Retention - Shelterwood System (Grouped Reserved Trees)	58
Even-aged Group Removal - Shelterwood Group System	60
Uneven-aged Systems	62
Uneven-aged Group Removal (Group Selection)	62
Intermediate Harvests	65
Commercial Thinning	65
Growth and Yield of Silvicultural Systems	67

SILVICULTURAL SYSTEMS

INTRODUCTION

The appropriate selection of silvicultural systems is critical in meeting management objectives for the Shasta Costa Planning Area. In this section, the silvicultural methods proposed for implementation in the Proposed Action and its alternatives are described, illustrated, and compared.

This appendix contains a discussion of considerations behind each of the silvicultural systems selected for the alternatives. The selection of the silvicultural systems proposed for each alternative were designed by the Interdisciplinary Team, with the application based on Standards and Guidelines of the Forest Plan, interpretation of inventoried stand data, and familiarity with stand conditions. In all cases, site specific stand information and on-site evaluation will provide the basis for a detailed silvicultural prescription prior to implementation.

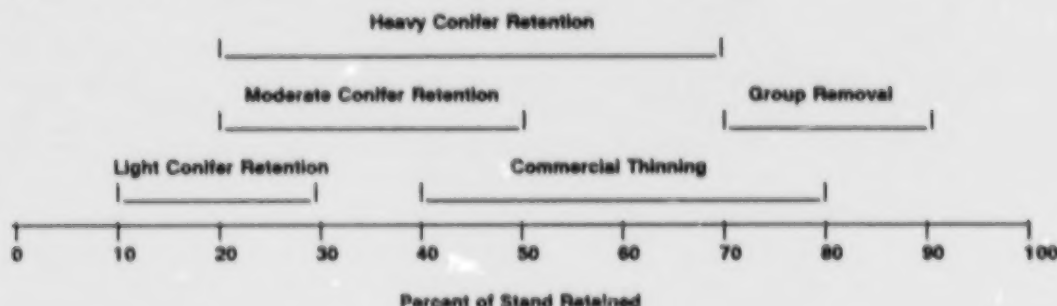
Interpretation of the Forest Plan in Shasta Costa offers a unique opportunity to explore alternative silvicultural approaches which incorporate New Perspectives. The New Perspectives concept emphasizes the incorporation of human needs and uses into stand and landscape strategies which maintain the diversity, productivity, and resilience of natural ecosystems.

Silvicultural approaches proposed in Shasta Costa include a blend of traditional and new techniques. Traditional silvicultural systems provided the basic "tool kit" for designing a range of systems that would be responsive to the integrated resource objectives identified for the Planning Area. The "tool kit" includes silvicultural systems which incorporate both even-aged and uneven-aged stand management systems. Even-aged systems are characterized by stands of trees that are approximately the same age throughout the rotation. Uneven-aged systems produce stands in which the trees within the stand usually have at least three distinctive age classes present. Even-aged and uneven-aged systems include regeneration harvest, with subsequent establishment of new seedlings, intermediate stand improvement treatments such as precommercial thinning and intermediate harvests such as commercial thinnings. These management techniques are applied commensurate with management objectives and appropriateness to the desired characteristics of the stand.

The "tool kit" also includes silvicultural systems which emphasize the retention of stand structural components. These components include live conifer reserve trees, standing and down large woody material, hardwood trees, and understory species, all of which help meet the present and future functional needs for wildlife habitat, long-term site productivity, and scenic and riparian protection.

Management objectives may be related to the amount of forest cover remaining following timber harvest. Figure B-1 displays the range, or continuum of the percent canopy cover retained by each of the silvicultural systems described.

Figure B-1. Continuum of Canopy Cover Retained by Silvicultural System



EVEN-AGED SYSTEMS

Even-aged systems are known by the type of regeneration cutting method employed. Clearcut, seed tree, and shelterwood are the major even-aged methods of regeneration. Each of these methods includes the retention of green trees on site, though the methods differ in the quantity and distribution of trees retained. Clearcut, seed tree, and shelterwood should not be thought of as distinct cutting methods, but as parts of a continuum in which the amount of the residual stand can be varied to best meet management objectives for the site.

Most stands in the planning area have developed relatively even-aged structures; age class distributions are within 20 percent of the rotation age. These stands are primarily suited for management with even-aged silvicultural systems.

Even-aged systems schedule regeneration immediately following final harvest of the previous stand. Advantages of even-aged systems include limited management entries and higher likelihood of success at controlling and tracking stand development and treatment needs. Competing vegetation is more easily controlled with even-aged systems when compared with uneven-aged systems.

Even-aged systems provide stand conditions that are particularly favorable for the regeneration and development of shade intolerant conifers such as Douglas-fir and sugar pine. With these systems, sufficient openings are created for establishment and growth of intolerant species.

Even-aged systems typically result in a mosaic landscape pattern composed of patches of different successional stages. The size of individual patches typically range from two to 60 acres. The distribution of patches in time and space will determine the degree of fragmentation of the landscape and the diversity of successional stages, so that the functional size of a patch or group of patches can be much higher.

Even-aged methods vary in the amount of structural diversity provided at various times in the rotation. Structural diversity can be manipulated through the amount, distribution, and duration of overstory and edge trees retained.

The number, distribution, and duration of residual overstory trees left on site varies with even-aged systems. Variation in overstory and amount of edge retained cause variation in success of natural and artificial regeneration, cost and effectiveness of intermediate stand treatments, and stand growth and yield. Increasing amounts of residual overstory trees and stand edge generally enhance regeneration but may reduce growth and yield if shading and other competitive factors are significant. Stand modeling and personal communication with researchers indicate that leaving overstory trees may reduce growth and yield of young Douglas-fir stands up to 20 percent over a rotation, depending on the number of trees left and site quality (See the Growth and Yield discussion later in this appendix.)

Even-aged systems are characterized by relatively long periods between harvest entries. Harvest entries during the rotation are typically limited to one to three commercial thinnings and one final harvest. Transportation system densities are typically lower than those with uneven-aged systems, and transportation networks are used less frequently. This allows for periods of rehabilitation and stabilization for certain resources between management entries. Soil, watershed, wildlife, and visual resources are often enhanced by this extended period between entries.

With even-aged systems, soil exposure and compaction from each harvest entry generally occur over a larger portion of the stand than with uneven-aged systems. However, even-aged systems require fewer entries with extended periods of rehabilitation between entries. Soil exposure and compaction will vary according to the logging method used. Ground-based systems generally result in greater soil exposure and compaction than helicopter yarding systems.

Activity-related fuels and competing vegetation can be managed much more efficiently with an even-aged system. With proper planning and under appropriate conditions, post-harvest fuels can be treated with relatively low cost and low risk to overstory and edge trees. Similarly, hardwoods and shrubs can be cut or burned promptly before regeneration, giving the new conifer seedlings a competitive advantage over the other vegetation. Direct treatment of unwanted vegetation is also more efficient and less costly with even-aged systems.

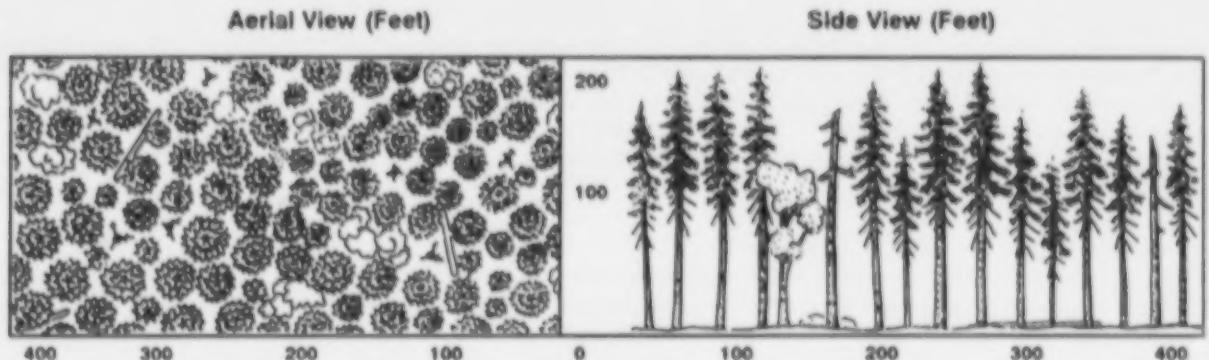
Even-aged systems are sometimes used to convert hardwood stands to conifer stands. Conversions are only prescribed on suitable sites where management objectives, including wildlife habitat and species diversity, are best met by conifer species. Hardwood stands often have an overstory of scattered remnant conifers. Hardwood conversion prescriptions include retention of all or a portion of these conifer remnants for wildlife habitat, long-term productivity, and structural diversity through entire rotations or portions of rotations (Forest-wide Standards and Guideline 6-13).

The Silvicultural Systems described in this appendix, pages B-4 through B-15, are divided into four categories: even-aged systems, uneven-aged systems, intermediate harvest, and commercial thinning. Each of these categories is described and compared, and followed by a series of drawings which present a chronological visual presentation of each system. Each series of drawing offers both an aerial view and a side view of the stand prior to harvest, immediately after harvest, and several decades after harvest.

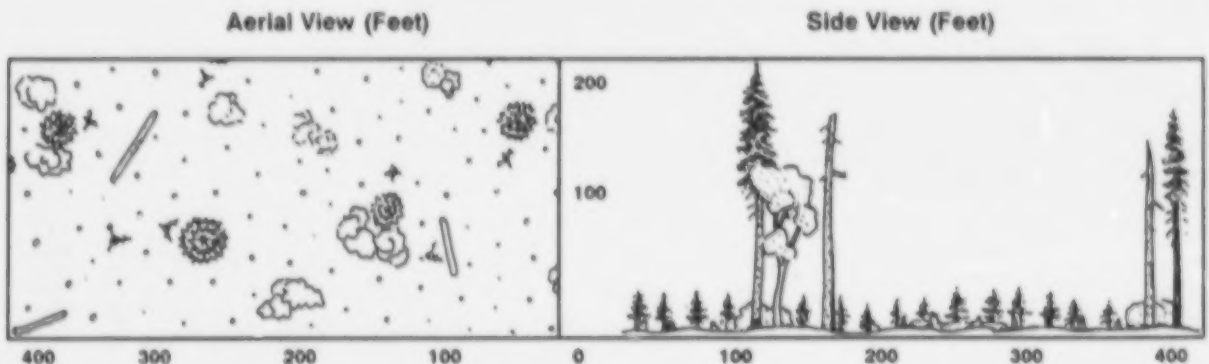
LIGHT CONIFER RETENTION - CLEARCUT

Description

A clearcut is an even-aged silvicultural system in which nearly all of the merchantable trees in a stand are harvested. Some trees are reserved, however, and left for wildlife uses, riparian protection, long-term productivity, species diversity and other resource needs. Unmerchantable vegetation, such as brush, typically will be felled when logs are yarded to the landing. Groups of hardwood brush species are purposely retained to provide a level of species and structural diversity. Clearcutting is to be prescribed only where it is determined to be the optimum method to meet management objectives (Forest Plan Standard and Guideline 6-7). Conditions which might lead to a clearcut prescription include high windthrow potential, lack of suitable conditions for natural regeneration, stand conversion is warranted, and/or visuals, wildlife, and other resource objectives can be met without leaving additional trees on the site. Regeneration is most often obtained by planting, though sometimes stand and site conditions are favorable for natural regeneration. Even when clearcut units are planted, natural regeneration from adjacent seed sources will typically fill in among planted trees, especially on the more productive sites. The following illustrations show how light conifer retention systems typically appear and develop through time.



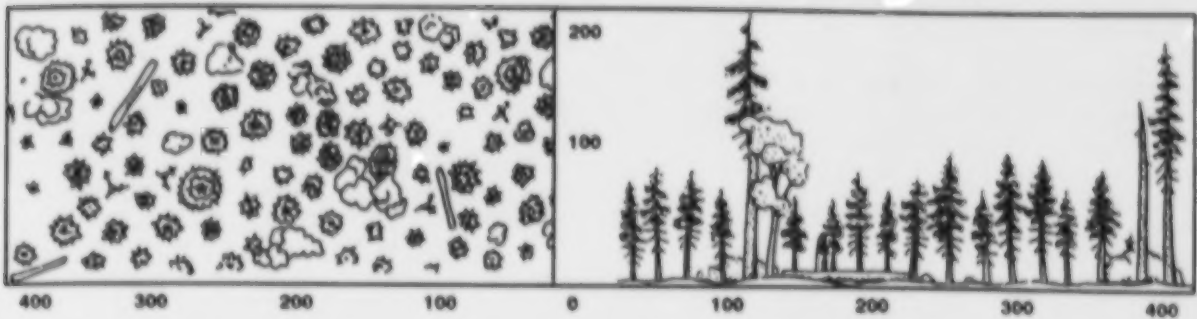
DATE 1990 - This stand is even-aged and mature to overmature. Many trees are becoming decadent. Individual trees are showing thinning crowns and broken tops. There is some individual tree mortality. The dying and dead trees create openings in the canopy which promote the growth of understory brush and hardwood vigor.



DATE 1993 - Clearcutting has removed nearly all merchantable trees in this stand. Groups of green trees and snags are reserved for wildlife, riparian protection, long-term productivity, and species diversity.

Aerial View (Feet)

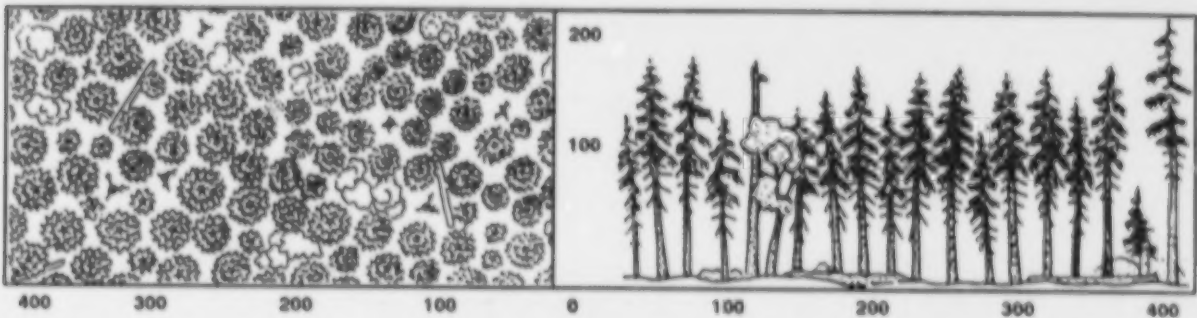
Side View (Feet)



DATE 2023 - Thirty years after clearcutting, reserve trees are aging and are serving as replacements for those snags which have fallen during the previous three decades. Younger stand vigor is maintained by management activities during the past three decades that may have included release from competing vegetation, pre-commercial thinning, and fertilization.

Aerial View (Feet)

Side View (Feet)

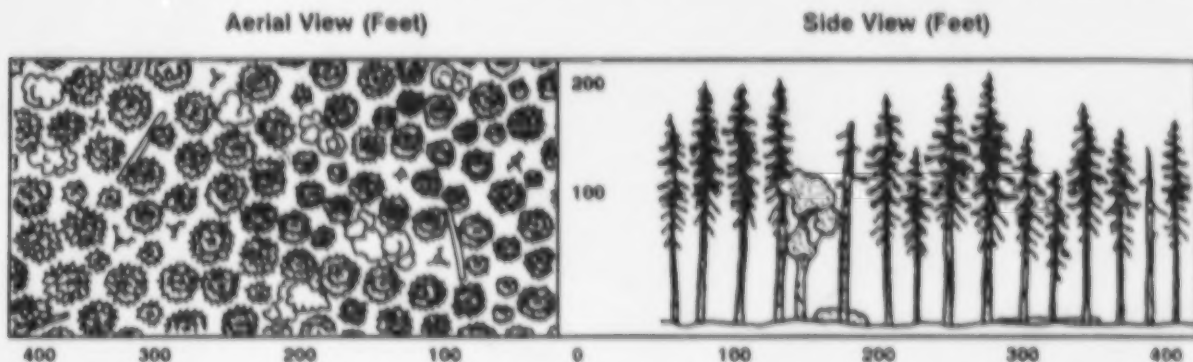


DATE 2053 - Sixty years after clearcutting, the stand canopy is closing. Individual tree growth is beginning to decline and a commercial thinning may now be appropriate.

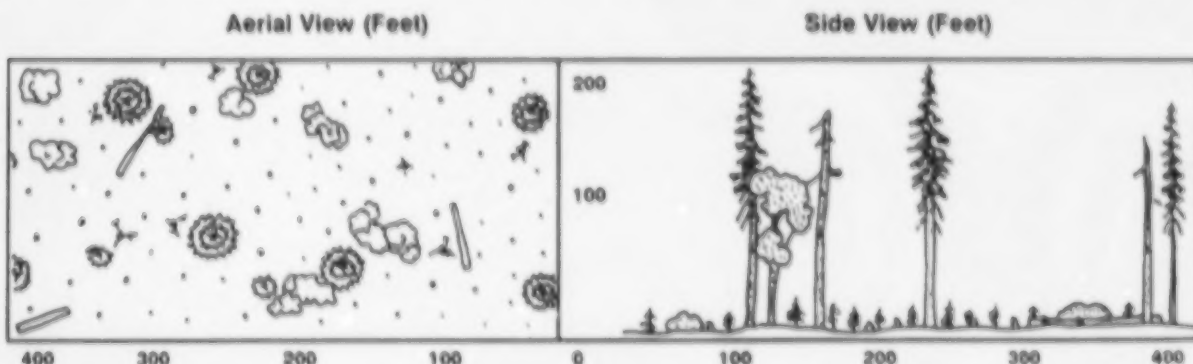
MODERATE CONIFER RETENTION - SEED TREE

Description

The seed tree system with high forest reserves is an even-aged silvicultural system similar to the shelterwood systems except that reserve trees are generally fewer and more widely distributed. While reserve trees are primarily intended for seed dispersal, they may serve concurrent functions such as providing snag habitat for cavity-nesting wildlife species, visual screening, long-term productivity, and/or maintaining structural diversity through entire or portions of rotations. This method is most appropriate where the potential for natural regeneration is good. Planting is not uncommon to supplement species diversity or ensure prompt reforestation. The following illustrations show how moderate conifer retention systems typically appear and develop through time.



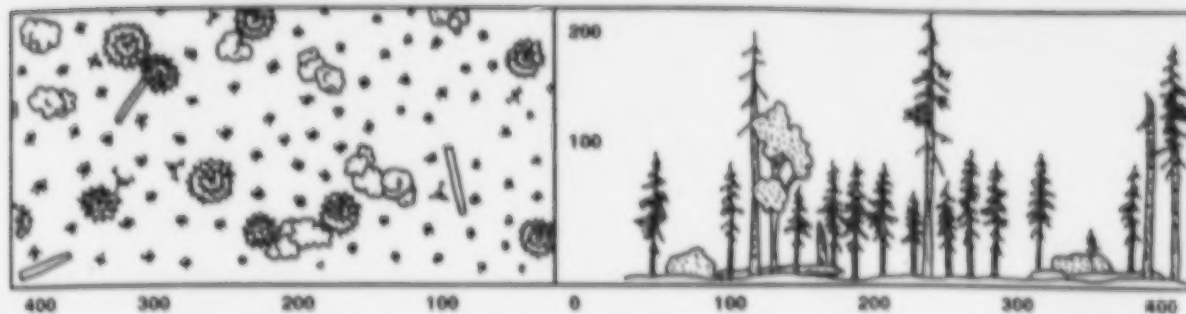
DATE 1990 - This is an even-aged mature and overmature stand exhibiting decadence with thinning crowns, and mortality creating openings in the canopy. These openings promote understory brush and hardwood vigor.



DATE 1993 - The seed tree harvest system reserves widely distributed trees as natural seed sources. Additional benefits enhance wildlife, soil, and visual resources.

Aerial View (Feet)

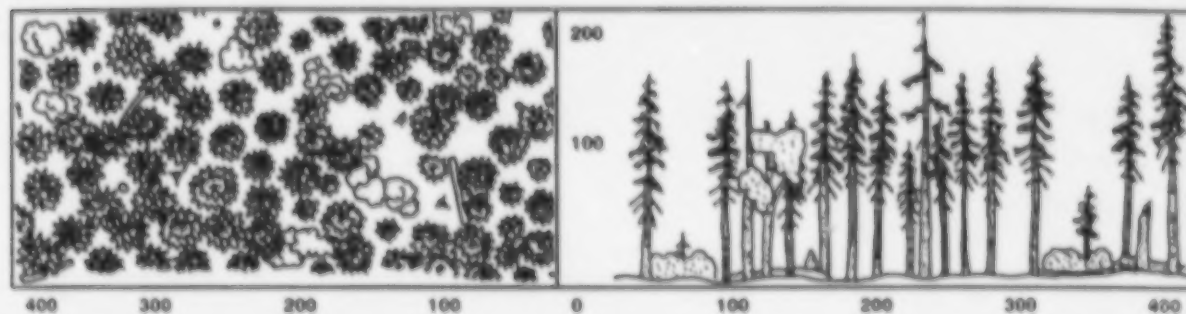
Side View (Feet)



DATE 2023 - Thirty years after harvest, the stand continues to develop. Reserve trees retained from the original stand serve as replacement snags for those that have fallen during the previous three decades.

Aerial View (Feet)

Side View (Feet)

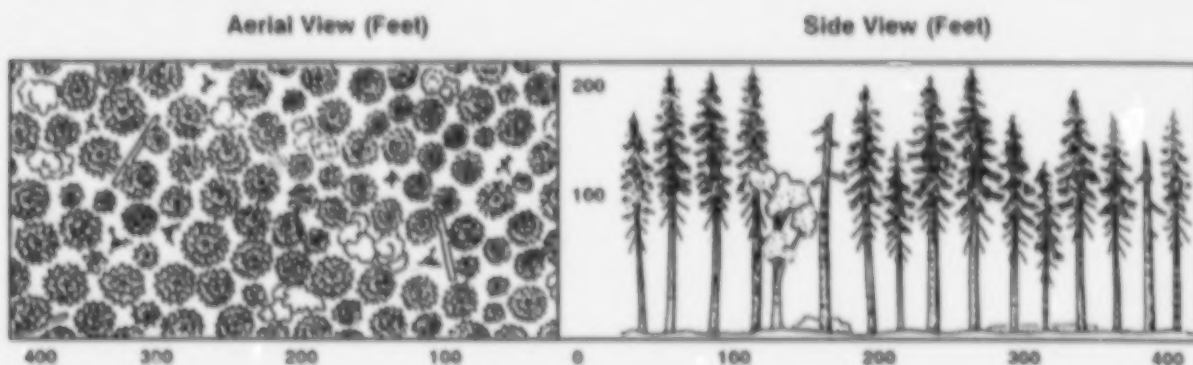


DATE 2053 - Sixty years following harvest, the stand canopy is closing. Individual tree growth is declining and scheduling of commercial thinning may be appropriate at this time.

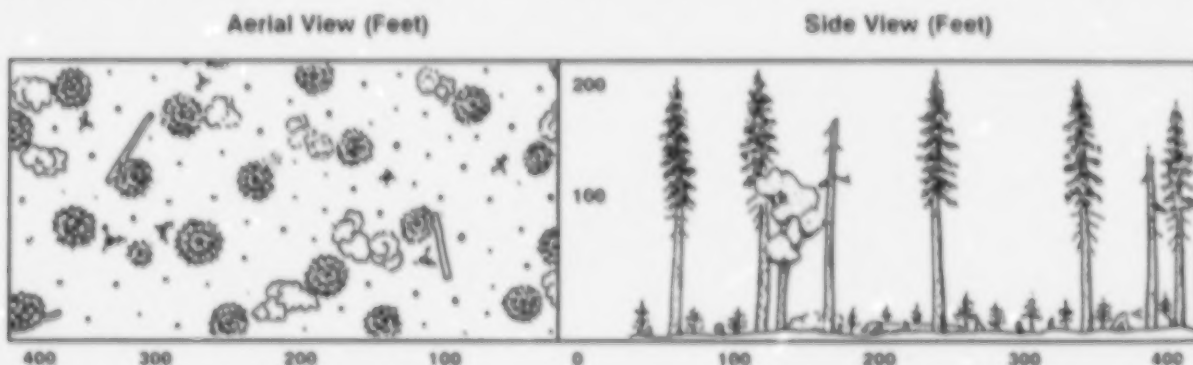
HEAVY CONIFER RETENTION - SHELTERWOOD SYSTEM (UNIFORM)

Description

The Shelterwood system is an even-aged system in which individual or groups of reserve trees are uniformly distributed throughout the stand. These residual trees will remain for all or part of the next rotation. Reserve trees are distributed in order to meet objectives for structural diversity, site amelioration, long-term site productivity, visual screening, and wildlife habitat. Regeneration is typically through natural seeding. Planting may be used, however, in order to supplement species diversity and to ensure prompt reforestation on drier sites. The shelterwood system is used primarily to provide a protected environment to enhance seedling survival through the establishment period. The reserve trees also help to meet additional resource management objectives including interception of rain and snow, and an increased evapo-transpiration surface in areas of higher watershed sensitivities. Stands managed under this system may develop an uneven-aged structure over the course of the rotation.



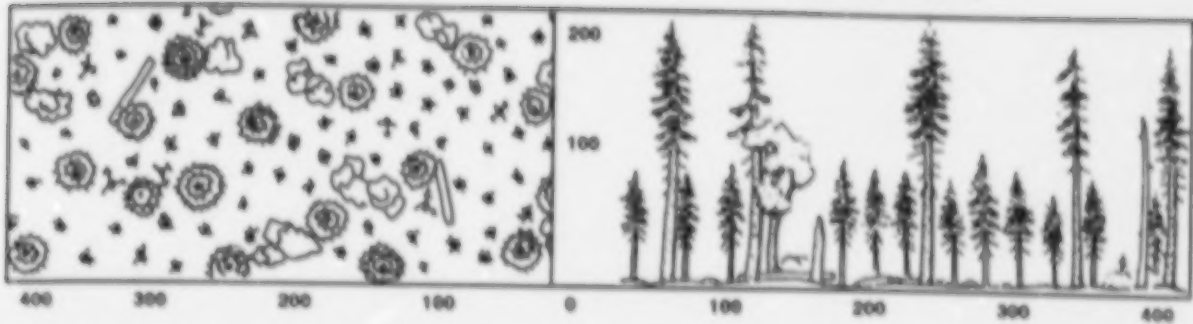
DATE 1990 - This stand is even-aged and mature to overmature. Many trees are becoming decadent. Individual trees are showing thinning crowns and broken tops. There is some individual tree mortality. The dying and dead trees create openings in the canopy which promote growth and vigor of understory hardwoods and brush.



DATE 1993 - This shelterwood system results in the harvest of the majority of the trees in the stand. Reserve trees from the existing stand are dispersed uniformly across the harvested area. Reserve trees provide protection for young trees, as well as natural seed sources for reforestation, visual screening, watershed protection, and wildlife habitat. Reserve trees, shrubs, hardwoods, and standing/down woody material are retained for species diversity and long-term productivity.

Aerial View (Feet)

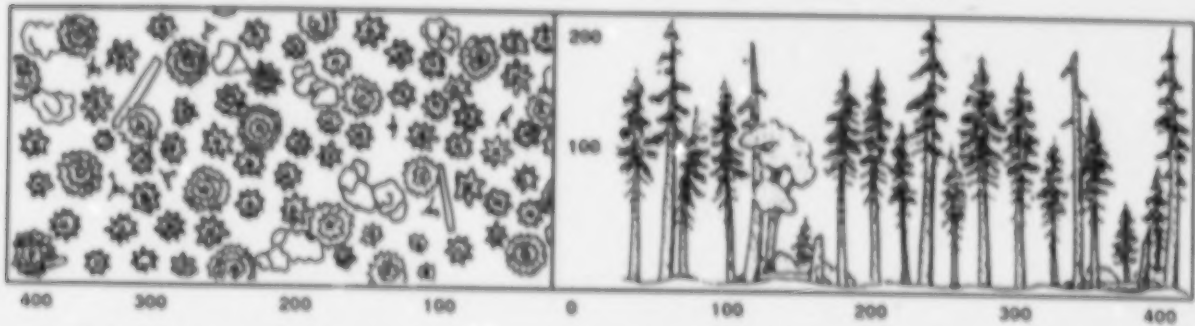
Side View (Feet)



DATE 2023 - Thirty years after harvest the stand exhibits both overstory and understory structure. Overstory structure is provided by the residuals retained from the initial harvest, with understory structure provided by the re-established stand.

Aerial View (Feet)

Side View (Feet)

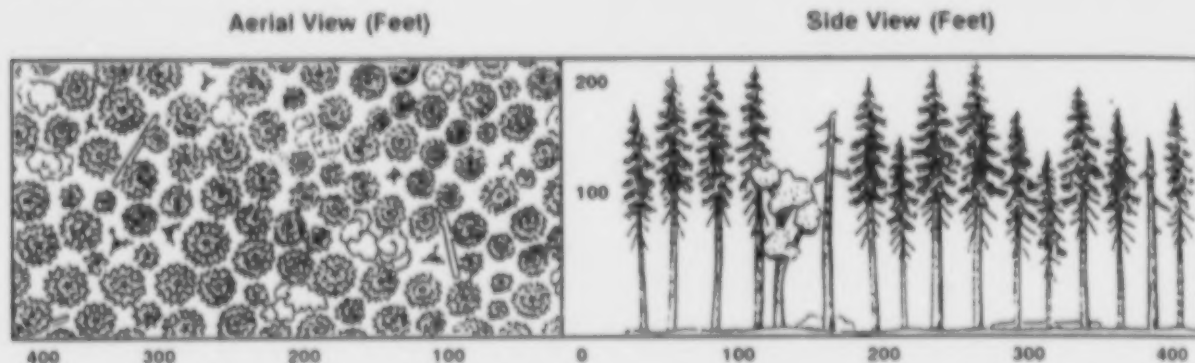


DATE 2053 - Sixty years after initial harvest, the canopy is closing. Individual tree growth is declining as competition within the stand increases. The stand is ready for commercial thinning.

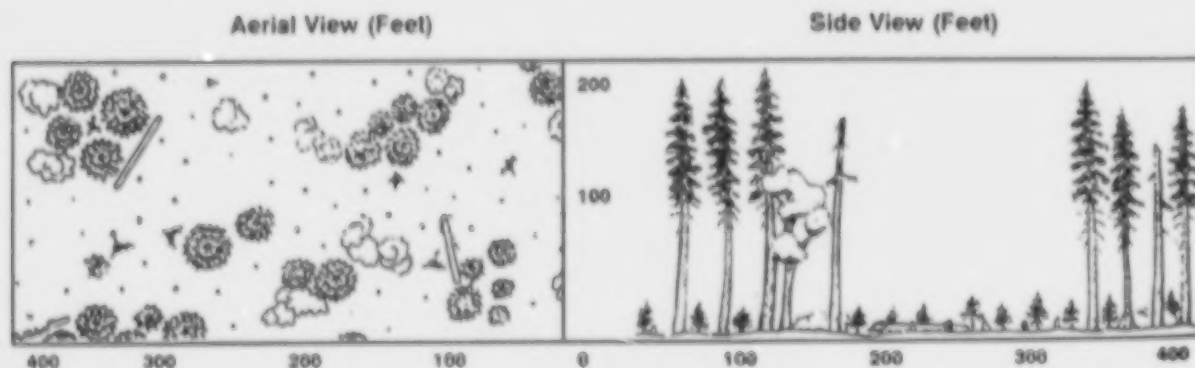
HEAVY CONIFER RETENTION - SHELTERWOOD SYSTEM (GROUPED RESERVED TREES)

Description

The Shelterwood System with Grouped Reserve Trees is an even-aged system in which reserve trees are either scattered or grouped unevenly throughout the stand. These residual trees will remain for all or part of the next rotation. Reserve trees are distributed in order to meet objectives for structural diversity, site amelioration, long-term productivity, visual screening, and wildlife habitat. Regeneration is typically through natural seeding. Planting may be used, however, in order to supplement species diversity and to ensure prompt reforestation on drier sites. The shelterwood system is used primarily to provide a protected environment to enhance seedling survival through the establishment period. The reserve trees also help to meet additional resource management objectives including interception of rain and snow, and an increased evapo-transpiration surface in areas with higher watershed sensitivities. Stands managed under this system may develop an uneven-aged structure over the course of the rotation. The following illustrations show how the grouped reserve tree method typically appears and develops through time.



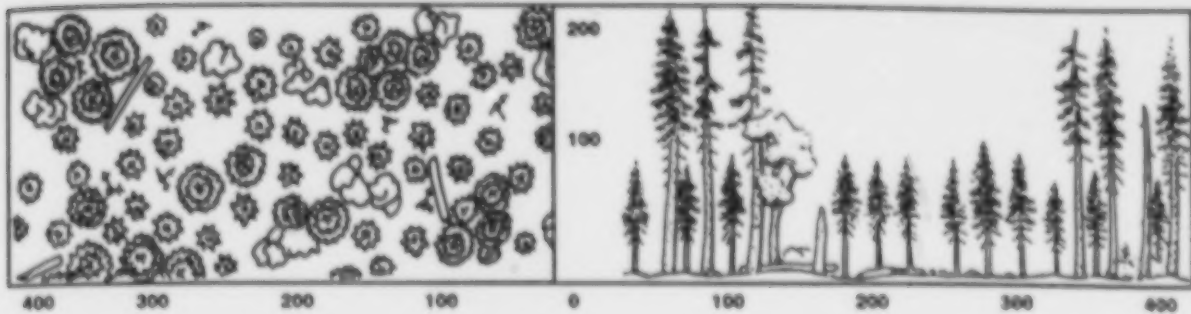
DATE 1990 - This stand is even-aged and mature to overmature. Many trees are becoming decadent, with individual trees showing thinning crowns and broken tops. There is some individual tree mortality. The dying and dead trees create openings in the canopy which promote growth and vigor of understory hardwoods and brush.



DATE 1993 - This shelterwood system results in the harvest of the majority of the trees in the stand. The reserve trees provide protection for young trees, seed for natural regeneration, visual screening, watershed protection, and/or wildlife habitat. Reserve trees, shrubs, hardwoods, and standing/down woody material are retained for species diversity and long-term productivity.

Aerial View (Feet)

Side View (Feet)



DATE 2023 - Thirty years after harvest the stand exhibits both overstory and understory structure. Overstory structure is provided by the residuals retained from the initial harvest, with understory structure provided by the re-established stand.

Aerial View (Feet)

Side View (Feet)

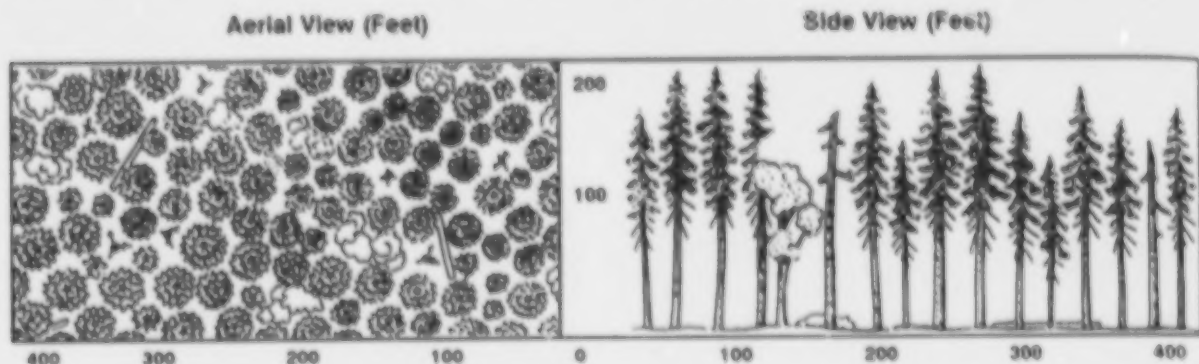


DATE 2053 - Sixty years after initial harvest, the canopy is closing. Individual tree growth is declining as competition within the stand increases. The stand is ready for commercial thinning.

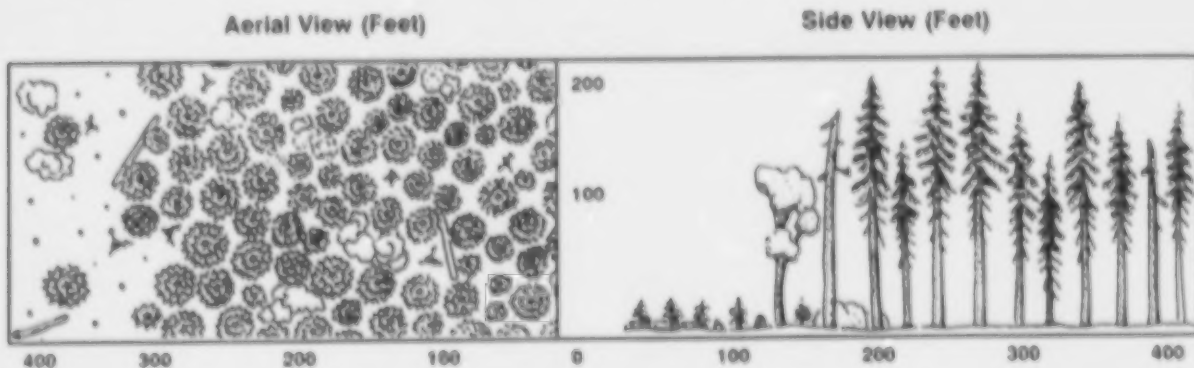
EVEN-AGED GROUP REMOVAL - SHELTERWOOD GROUP SYSTEM

Description

The shelterwood group system is an even-aged silvicultural system in which groups of trees are harvested in a design which utilizes adjacent stands for seed and/or protection for regeneration. Harvest units generally range in size from two to five acres and are composed of groups of relatively even-aged structures. Some reserve trees are left in the openings for riparian, wildlife, long-term productivity, species diversity, and other resource needs. Regeneration is primarily natural, though often supplemented by planting. Adjacent portions of the stand are harvested in increments after regeneration is established and resource objectives are met. The following illustrations show how the shelterwood group systems typically appear and develop through time.



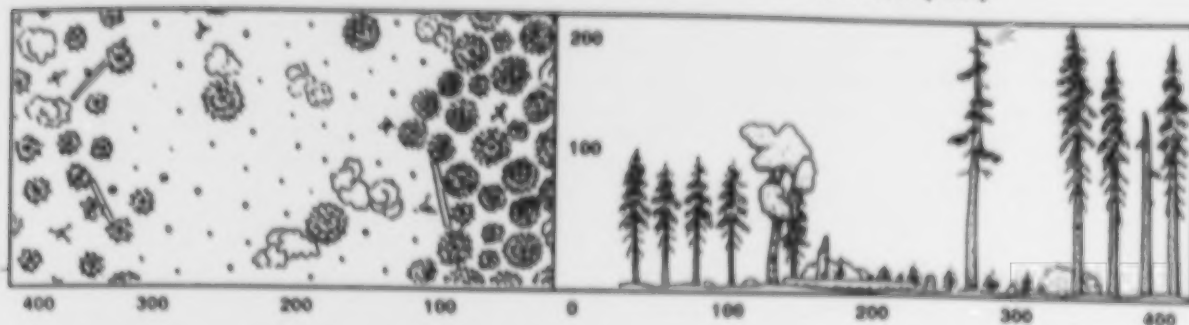
DATE 1990 - This is an even-aged mature to overmature stand exhibiting thinning crowns and some individual tree mortality. Openings in the canopy promote vigor of understory brush and hardwoods.



DATE 1993 - The shelterwood group system harvests groups of trees while utilizing adjacent stands for seed sources and/or protection. These small openings can enhance the seedling environment, screen activities, and minimize watershed/wildlife impacts. Hardwoods and standing/down dead woody material are retained for biological diversity and long-term site productivity.

Aerial View (Feet)

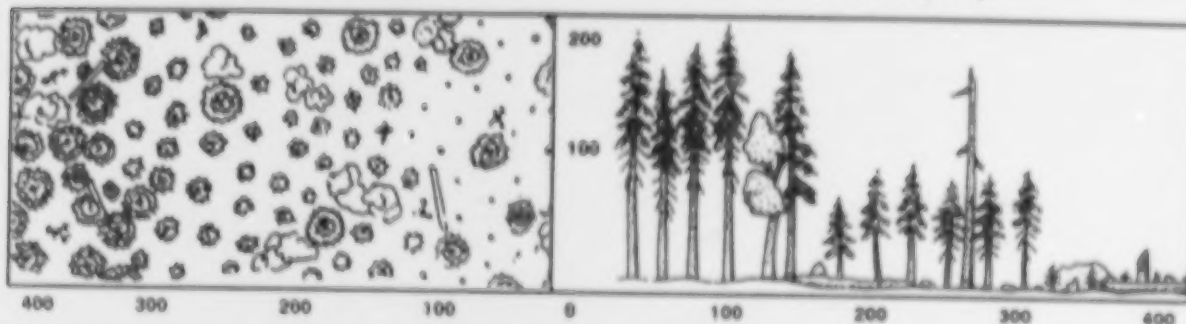
Side View (Feet)



DATE 2023 - Thirty years after the initial entry, a vigorous stand is developing, resource objectives have been met, and a new group of mature and overmature trees is harvested. Individual overmature trees are retained as replacement snags.

Aerial View (Feet)

Side View (Feet)



DATE 2053 - Sixty years after the initial entry, a third entry is planned. It is often beneficial to have progressive entries face away from the incoming solar angle, sensitive viewpoints, or downslope buffers.

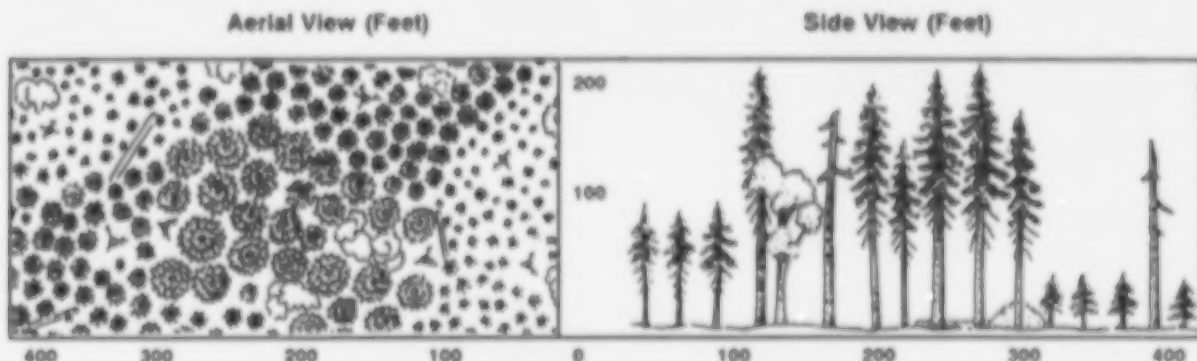
UNEVEN-AGED SYSTEMS

Uneven-aged systems include group selection and single tree selection. The group selection method is prescribed for two sites in two Shasta Costa alternatives (B and H) and is described on the following page. The single tree method, in which single trees are removed at relatively short intervals, was not considered the most appropriate method for sites in the Shasta Costa Planning Area. It is not discussed because existing stand conditions where uneven-aged management is applicable have primarily developed group structures.

UNEVEN-AGED GROUP REMOVAL (GROUP SELECTION)

Description

The Group Selection System is an uneven-aged silvicultural system in which small groups, averaging one to two acres in size, are periodically harvested from larger stand areas. This system is used to progressively regenerate and manage stands with an uneven-aged class distribution or where encouraging an uneven distribution would best meet management objectives. There are stands in the Shasta Costa Planning Area with uneven-aged structures with shrub and hardwood components. This system can be effective where moderate to low levels of competition are expected, but poses some risk where competition from unwanted vegetation is heavy. The following illustrations show how the group selection system typically appears and develops through time.



DATE 1990 - The stand is composed of a variety of age classes. These are groups of mature to overmature trees, immature trees, and seedlings/saplings distributed randomly through the stand.



DATE 1993 - The group selection harvests groups of mature and overmature trees, leaving old growth remnants, scattered hardwoods, and standing or down dead woody material. Trees of various ages including mature and overmature classes remain undisturbed adjacent to the harvest area.

Aerial View (Feet)

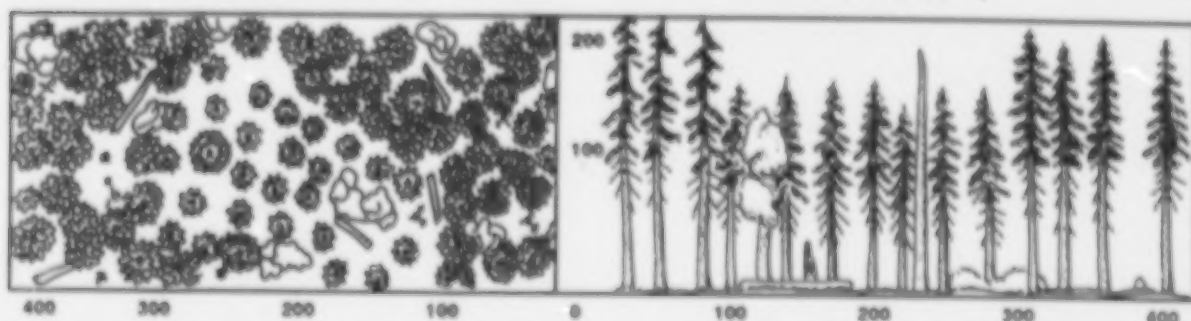
Side View (Feet)



DATE 2023 - Thirty years later, the opening created by previous harvest has been occupied by vigorous young trees. Harvest of mature and overmature components is occurring elsewhere in stand.

Aerial View (Feet)

Side View (Feet)



DATE 2053 - Sixty years after the initial entry, harvest of new groups of mature and overmature trees is beginning. This harvest again retains old-growth remnants, scattered hardwoods, and standing/down dead woody material.

The group selection method is appropriate on a limited number of sites in the planning area. Most existing stands have naturally developed a relatively even-aged structure. It is difficult, time-consuming, and risky from a vegetative competition standpoint to convert to uneven-aged structures. Existing vegetation and soil conditions, and interpretation of plant associations indicate moderate to high response can be expected from hardwoods and shrubs following disturbance on most sites. This response impedes uneven-aged management. Natural regeneration, prevention and control of competing vegetation is difficult. The resulting scattered small openings make site preparation, planting, monitoring, and scheduling/implementing necessary followup treatments costly and difficult.

Isolated stands have naturally developed uneven-aged structures with multiple age classes from repeated low-high intensity fires, and/or have manageable understories which may be compatible with uneven-aged systems.

The change in vegetative cover brought about by the group selection method is more subtle than with even-aged systems. In the Shasta Costa Planning Area, harvest activities under the group selection system are dispersed within a stand over approximately 20 percent of the area, with subsequent entries on intervals of approximately 20 percent of the rotation. The 20 percent parameter is based on watershed, soil, and visual considerations as well as stand conditions. The uneven-aged stand created is a mosaic of very small even-aged groups or aggregations of two acres or less. These aggregations represent randomly distributed progressions of successional stages.

An initial analysis on the feasibility of incorporating the group selection system on specific sites in Shasta Costa has been conducted utilizing the Siskiyou National Forest's *Vegetation Damage Thresholds/Uneven-Aged Management Opportunities by Plant Association* (McCullough, 1989). This analysis assesses uneven-aged management opportunities based on interpretations of the plant associations for the Siskiyou Mountain Province.

The group selection method may have a tendency to provide stand conditions that are unfavorable to the shade intolerant conifers if the size of openings do not allow enough sunlight for seedling development. This would detract from the stand's species diversity. Genetic diversity could also be impacted by the selection of cut/leave trees, and regeneration success. Planting may be necessary to ensure gene pool diversity.

Structural diversity can be enhanced with the group selection method, both in vertical and horizontal distribution, as small openings create even-aged clumps of early successional vegetation. While enhancing structural diversity, uneven-aged systems create a higher proportion of edge and fragmentation. The relatively frequent cutting cycles and other stand tending activities may offset the potential benefits of maintaining a high forest cover for species that are sensitive to periodic disturbance and displacement.

Uneven-aged systems are characterized by relatively short periods between harvest entries. Higher transportation system densities are typical with uneven-aged systems to effectively access the stands without causing excessive damage during harvest operations. Helicopter harvesting may reduce the need for additional roading during harvest operations, but will significantly increase costs of fuels treatment, reforestation, vegetation management, and pre-commercial thinning.

Soil and watershed risks are proportional to the amount of vegetation removed, bare mineral soil exposed, and percent of soil surface compacted. Uneven-aged management has potentially the least impact due to the amount of stand area left undisturbed per entry. The potential for surface disturbance, compaction, and erosion increases depends largely on the type of logging system used. Highest impacts are associated with ground-based systems and lowest impacts with helicopter systems.

The group selection system adds to the difficulty of managing activity-related fuels and the risk of wildfire. Multiple canopy layers provide fuel ladders to potentially carry ground fire to crowns. Protection of the residual stand is more difficult and costly as small openings with accumulations of fuel are treated adjacent to young and older crop trees. Access may be limiting depending on yarding systems, causing logistical problems in moving work crews efficiently.

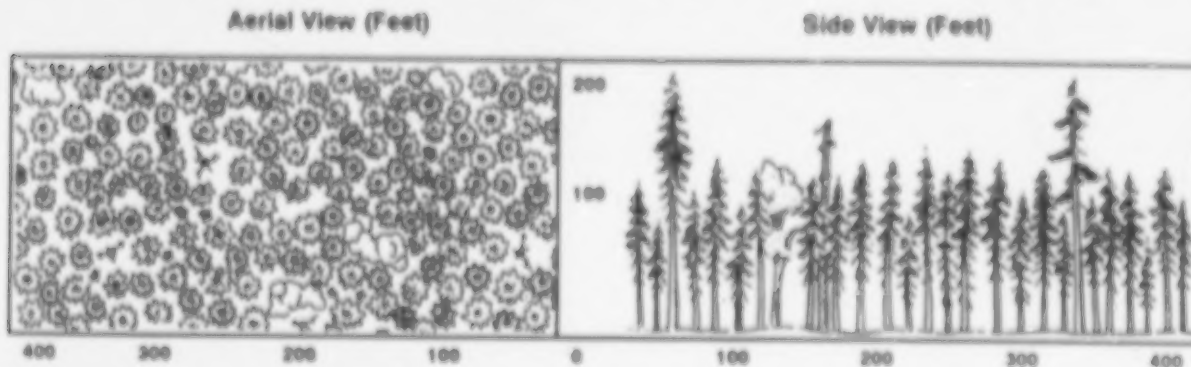
INTERMEDIATE HARVESTS

Intermediate harvests are selective cuts of immature stands designed to improve stand vigor and remove existing or impending mortality. Commercial thinning is an intermediate harvest activity proposed for several stands in Shasta Costa alternatives.

COMMERCIAL THINNING

Description

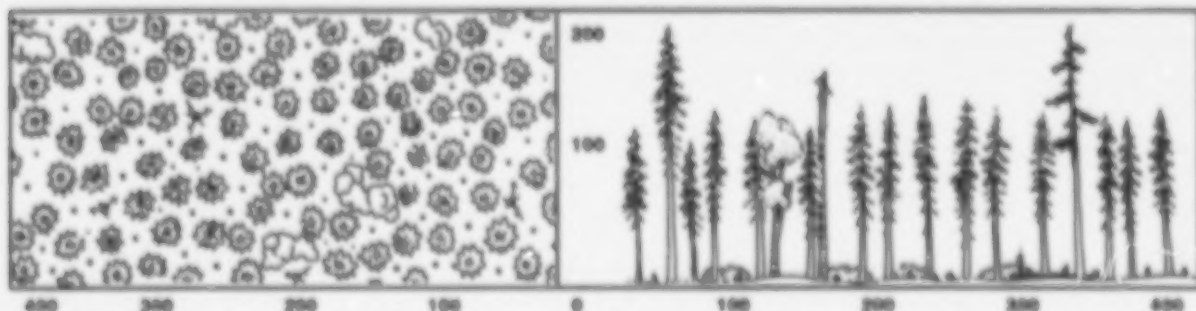
Commercial thinning is used as an intermediate harvest treatment in overstocked immature conifer stands. Commercial thinning allows for harvest of imminent mortality and provides the remaining trees with more light, moisture, and nutrients. This increases or maintains stand growth by redistributing growth among the remaining trees. The density of the remaining stand is normally determined by stand age, condition, and management objectives. In the Shasta Costa Planning Area, commercial thinning is being prescribed for stands in order to meet a variety of objectives including timber productivity, visual resources, wildlife habitat, and biological diversity. These objectives can be met by varying residual stand densities. For example, visual character and timber productivity objectives can best be integrated by retaining high stocking levels and planning additional commercial thinning entries, thereby extending the rotation. Wildlife habitat and vegetative diversity can be enhanced by opening the stand more, allowing increased sunlight and moisture to reach the forest floor promoting understory growth and ground cover. This results in increased vertical diversity. Commercial thinning can also hasten development of old growth by accelerating diameter growth for an extended period.



DATE 1990 - This is a densely stocked, immature conifer stand between 40 and 100 years old. The stand canopy is mostly closed. There are a few small openings occupied by hardwoods and brush, and a few scattered remnant old-growth trees.

Aerial View (Feet)

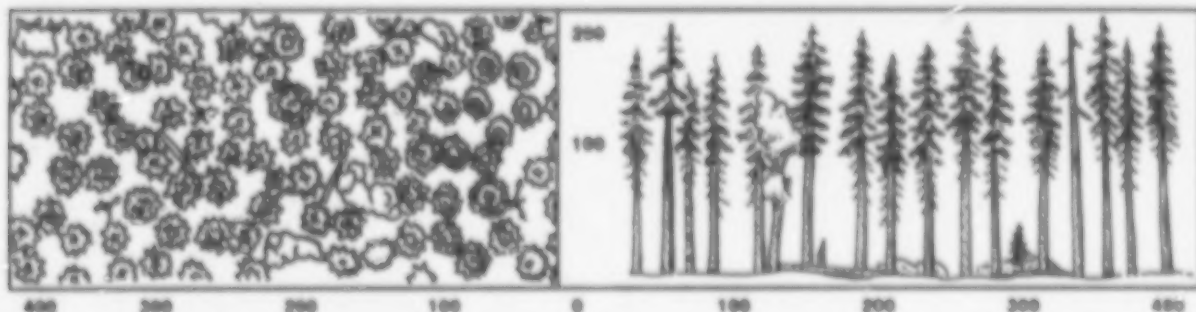
Side View (Feet)



DATE 1993 - Commercial thinning removes poorly growing and defective trees, most of which are found in the understory of the stand. This opens the canopy and provides more growing space for the remaining trees. Scattered remnant old-growth trees, snags, and hardwoods are intentionally left for structural and species diversity.

Aerial View (Feet)

Side View (Feet)



DATE 2050 - Twenty to sixty years after commercial thinning, the stand canopy has again closed. Individual tree growth has begun to decline due to overcrowding, with increased shading beneath the canopy, reducing understory growth.

Commercial thinning produces subtle changes in seral stage development. Thinning enhances diameter growth of the residual stand, thereby hastening the development of immature stands to mature and old-growth stages. As apposed to regeneration harvest, thinning does not affect patch size.

Commercial thinnings maintain stand vigor and tend to defer or prolong culmination of mean annual increment. Thinnings are useful management tools for holding stands for long rotations such as is often an objective in partial retention and retention management areas.

Soil and watershed risks are proportional to the amount of vegetation removed, bare mineral soil exposed, and percent of soil surface compacted. Commercial thinning generally results in low impacts to these resources. The potential for surface disturbance, compaction, and erosion increases depends largely on the type of logging system used.

Opening of the stand through commercial thinning encourages development of hardwood and shrub species in the lower strata. At this stage of stand development, the response of understory species do not typically cause competitive problems to the overstory conifers. However, prevention of unwanted competition is an on-going process. The intensity and timing of thinnings can affect the degree of response in the understory. Heavy thinnings provide extensive growing space which greatly enhances development of lower strata vegetation. Conversely, frequent, light thinnings may be used to maintain a narrow stocking range in which growth of conifers is maintained at favorable levels, while understory hardwoods and shrubs remain somewhat suppressed.

Commercial thinning, with treatment of activity-related fuels, may slightly lower wildfire risk. Thinning removes some vertical and horizontal fuel continuity, reducing the opportunity for fire spread.

GROWTH AND YIELD OF SILVICULTURAL SYSTEMS

Growth and yield simulations that compare unmanaged stands (natural growth trends) to managed stands have been prepared and summarized utilizing the Stand Prognosis Model (Wyckoff, et al.), Klamath Mountains Variant, Version 5.3. The Prognosis model was used to directly simulate development of stands in various even-aged methods prescribed for Shasta Costa alternatives. Because the Prognosis model is an individual tree based model (vs. stand average), interactions between trees, such as the overstory competition effect of reserve trees on young stand development and long term growth and yield, can be surmised.

The Group Selection system and the Shelterwood Group system could not be effectively simulated with available stand models to demonstrate adjacent timber/young stand interactions. Therefore, the Prognosis growth and yield projections developed for the shelterwood with high forest reserves were considered to approximate the intra-stand competitive factors that could be expected from the group selection system. Because of the increased distance between the average crop tree and overstory competition, the shelterwood group system is considered to approximate the Prognosis growth and yield projections for the seed tree method with high forest reserves.

The stand simulator for coastal Douglas-fir, DFSIM (Curtis, et al.), was used to model existing managed stands, and commercial thinning opportunities, primarily because of its use in developing management regimes and Forest Plan projections for the Siskiyou National Forest. The Managed Yield Tables for Siskiyou National Forest (Craig, 1984) provided the basis for developing management regimes for the simulation process.

Stand modeling was conducted on representative stands which were selected to reflect the range of productivity, age, stocking, and size classes on the planning area. Representative stands were stands included for treatment in one or more Shasta Costa alternatives.

Modeling commercial thinning for future managed stands (stands developed from regeneration of existing stands) were developed first using thinning ages and residual basal areas specified in Forest Plan yield tables for representative sites and management intensities. When used in Prognosis modeling, this method resulted in insufficient residual stocking beyond the first scheduled thinning, particularly on medium sites. To remedy this situation, the Event Monitor subroutine was utilized to monitor basal area development for the stand, and to impart a thinning regime based on established mean basal areas for stands under management from Managed Yield Tables for Siskiyou National Forest, page 12 (Craig, 1984).

Simulations to maximize merchantable board foot yields during a 130 year rotation were run, and compared to management regimes that did not thin the representative stands.

In general, the following gives an indication of growth and yield increases that might be expected from the commercial thinning regimes (throughout the rotation, as determined through modeling):

Site Index 1/	Commercial Thinning	Increase in MBF
150 ₁₀₀	1	20
120 ₁₀₀	1	8
100 ₁₀₀	1	19

1/ Scribner Rule, six inch top. Site indices 150₁₀₀ and 120₁₀₀ are combined in the analysis of alternatives for an average high site increase of 14 thousand board feet per acre, modeling for regeneration systems during the next rotation based on the maximum basal area potential for the site under management.

Mean basal area for high and medium sites (Site Index 120 and 110 (base age 100 respectively)), McArdle, et al., Managed Yield Tables, page 4) averages 280 and 219 square feet per acre respectively (Managed Yield Tables, page 12). Stands were grown to 1 standard deviation beyond the mean (120 feet² and 86 feet² respectively), and thinned back to the mean. An additional parameter that allowed no thinnings beyond the age of 130 years, (mean rotation age for management in partial retention management areas), was invoked.

The higher residual basal area parameter for high sites resulted in fewer thins being performed over the 130 year period. This resulted in lower overall productivity for the high sites, in terms of both quadratic mean diameter and board foot volume at culmination of mean annual increment.

This may either be a function of mean maximum basal areas for high sites being overestimated, or incompatibility of basal area parameters developed for the DFSIM model being used for projections in Prognosis. In either case, further study could be performed to resolve this apparent discrepancy.

Simulations performed for the clearcut, seed tree, and shelterwood methods displayed an effect of overstory retention on growth and yield. The clearcut system provided the baseline against which other methods were compared. The differences are displayed in merchantable board foot volume produced during the rotation and include cumulative total harvestable yield from the initial harvest, commercial thinnings, and standing volume at rotation age.

In general the following give an indication of growth and yield differences (as determined from the modeling) that might be expected from the retention of overstory throughout the 130 year rotation :

On High sites: Clearcut was baseline.

- Seed Tree was three percent less productive than Clearcut, yielding approximately five thousand board feet per acre less when overstories were retained throughout the rotation, and four thousand board feet per acre less when overstories were removed at the first commercial thinning.

- Shelterwood was eight percent less productive than Clearcut, yielding approximately 13 thousand board feet per acre less when overstories were retained throughout the rotation, and 12 thousand board feet per acre less when overstories were removed at the first commercial thinning.

On Medium sites: Clearcut was baseline.

- Seed Tree was thirteen percent less productive than Clearcut, yielding approximately 22 thousand board feet per acre less when overstories were retained throughout the rotation, and 11 thousand board feet per acre more when overstories were removed at the first commercial thinning.

Shelterwood was sixteen percent less productive than Clearcut, yielding approximately 26 thousand board feet per acre less when overstories were retained throughout the rotation, and 12 thousand board feet per acre more when overstories were removed at the first commercial thinning.

The differences in yields shown above appear to reflect the Prognosis model's projection of (1) the competitive effects of the residual overstory on the newly developing stand and (2) significant growth response of the overstory due to release from competition from stand conditions existing prior to the regeneration harvest, particularly on medium sites. These two factors appear to have compensating effects on growth and yield, thereby tempering the magnitude of the differences between the systems.

Other sources of information on this subject (unpublished documentation from the Willamette and Rogue River National Forests, and personal communication with researchers at the University of Washington and Oregon State University) have indicated that the above percentages may be conservative. Several sources independently speculated that differences between shelterwood and clearcut may be about 20 percent.

The differences shown above for the Prognosis projections on both sites may be conservative. The model showed a high response of the overstory to release from previous stand stocking conditions. Personal communication with researchers indicate there is some skepticism that mature and overmature trees would respond highly to release. This may be particularly questionable when considering that seed and shelter reserve trees are often selected for their ability to serve wildlife, visual, seed production, or other resource functions, rather than their ability to respond and release.

An additional basis for interpreting the Prognosis results as conservative, is the fact that windfall losses or additional snag recruitment needs are not considered in the model. District and Forest experience indicates that windfall losses of residual trees can be significant on some sites.

Further simulations were conducted to estimate differences in yields between systems in which reserve trees are retained for the length of the next rotation and systems in which reserve trees are removed during the first commercial thinning of the next rotation (when the new stand has developed to provide hydrologic and visual recovery). These simulations projected that, on high sites, and with a 130 year rotation, removal of reserve trees at the first commercial thinning increased stand slightly over the system in which reserve trees were retained for the entire rotation. On medium sites, removing reserve trees at the thinning resulted in stand yields that were up to 28 percent higher than yields obtained from retaining reserve trees through the 130 year rotation.

It must be emphasized that the growth and yield comparisons shown above are broad estimates based on modeling of a limited number of representative stands, and in the case of the DFSIM, simulations are gross extrapolations beyond 100 years. These figures must be interpreted with the knowledge that the data base behind the models lack information from stands developed under overstory competition. Their primary value is as a comparative tool to estimate relative effects of varying management regimes. The models also lack data on response of partial overstories following release from full stand conditions. There clearly is a need for long term studies on the dynamics and outputs of young stands and overstories developing together under a variety of site and stand conditions.

Documentation and analysis for the Shasta Costa modeling are available in the Planning Records.

APPENDIX 3. Process for Evaluating Significance of Old-growth Stands (Source: Lowell Ranger District, Willamette National Forest 1990)

PROCESS FOR EVALUATING SIGNIFICANCE OF OLD-GROWTH STANDS

Lowell Ranger District
Willamette National Forest
6/21/90

This document contains a description of a process to evaluate the significance of old growth stands, and explanations of the criteria used. This was originally conceived in the context of implementing the Forest Plan and establishing landscape management strategies for implementation. It has also contributed to implementing Section 318 (Hatfield/Adams) for FY 90. The main idea is to establish a framework for assessing old growth both at the landscape level and at the stand level.

At the landscape level the focus was to first establish priorities for the larger more significant blocks of old growth, and to then identify connective corridors between those blocks of old growth. The key idea in this approach is that we need to assess significant old growth both for its value as a block and for its value as a connector. To do that we need to look at a fairly large scale. We did this for a 22,000 acre area representing a logical chunk of a major watershed. The other main idea was to establish a scaling system based on ecological criteria to help prioritize the significance of the stands. The criteria we used and the process we followed are described in this paper.

At the stand level we need to take a second look at significant old growth to screen for unique characteristics and validate the broader landscape level assessment. At project design time we should have better information than we have for the broader analysis. Unique features of a stand (e.g., size, age, structural characteristics, or plant association mixes) may be significant on its own merits regardless of stand size, and without considering or providing for linkages to a broader network.

We've considered and tested lots of criteria and approaches. I'm sure there are lots more questions to answer and approaches to test. However, this approach has been workable for us and appears to meet the analysis needs.

OVERVIEW OF PROCESS

- I. Develop a stand type map
- II. Define or delineate the stand into blocks
- III. Conduct evaluation of blocks to rate significance
- IV. Landscape management strategy

The Process:

I. Develop a stand type map

1. Delineation of all stands which meet the PNW-447 definition for old-growth.
2. Delineation of all the other stand conditions which do not meet the PNW-447 definition.
3. Delineation of Class I-III streams and subdrainage boundaries

This information can be collected from a number of sources:

- Aerial photos
- TRI information and mapping of managed stands
- Stand examinations and field walk-thru
- Environmental Assessment documents; silvicultural and fuel prescriptions
- Mature and Overmature stand type mapping and attribute files
- Timber sale records; sale maps, sale prospectus, summary of cruise data.
- Specific district knowledge about stand conditions

II. Define or Delineate the Stands into Blocks

1. Determine "Interior Habitat Stand" boundaries for old-growth stands meeting the PNW-447 definitions by buffering in approximately two tree heights (400')
2. Identify the blocks using:
 - * Interior habitat stand boundaries
 - * Timber type patterns.
 - * The size, shape and continuity of the stands.
 - * Topographic features (ie, Class II subdrainages, ridges and streams)

After the interior stands boundaries have been outlined, the stand need to be defined into individual blocks to be rated. Delimiting stand boundaries may be an iterative or cyclic process for some stands. We delineated some stands in several ways to see how it worked. In general you should avoid splitting the stand to account for the full size of the stand. However, there were two reasons we split some large stands:

- a) The stand consisted of one large fairly intact block, and a highly fragmented piece attached to the block.
- b) A long relatively narrow stand spanned several subdrainages with several large lobes.

The following is the rating scheme we have evolved to at this time. The stands are put through a evaluation using the following criteria. A point rating would be given for each criteria and then summed for a total score. The range of scores were then grouped into HIGH, MEDIUM, and LOW significance categories.

1) Does the stand meet PNW Bulletin # 447?

* Rate stand according to the degree inwhich it meets the old-growth definition.

- has intolerants, tolerants, and structure, but not snags & logs 3 pt.
- above plus snags or logs 6 pt.
- meets 447 fully 10 pt.

2) What is the size of the interior habitat stand?

* Categories of acreages

- <100 acres 3 pt.
- 100-300 acres 5 pt.
- 300-500 acres 7 pt.
- >500 acres 10 pt.

3) Where is the stand positioned in the landscape? (topographic stability)

* Position in landscape

- patch on slope 3 pt.
- entire slope (Class I, II, or III stream to ridge) 6 pt.
- entire watershed (Class III or IV stream) 10 pt.

4) Are there any unique features in the stand?

- very large diameters (>70" DBH)
- very tall trees (>270' tall)
- very old stand (>600 years)
- unique plant communities or associations
- diversity:
 - structural (snag patches, unusual canopy structures, etc.)
 - plant association mixes or micro-habitats (hardwoods, wet areas, cliffs, etc.)

We treated these as bonus points giving 2 points per feature if they were merely present in some spot in the stand, and 4 points per feature if they were widespread in the stand.

5) Recreational/aesthetic

- significant evidence of human intrusion 3 pt.
- minor evidence of human intrusion 6 pt.
- no evidence of human intrusion 10 pt.

There may be other good reasons to split a stand such as one portion consists of very high quality, diverse old growth and another portion contains very marginal old growth.

We dealt with inclusions differently depending on what was included. If there was a patch of medium-sized timber (8-21"dbh) in the middle of a large block of unroaded old growth we considered it as part of the stand, and may have even given it a bonus for increased diversity. If there was a plantation with a road to it in the middle of the old growth block, we buffered around it and evaluated the remaining interior habitat as a stand. I think the presence of significant edge effects, especially from past salvage, would be the key.

In a majority of our stands, we lack specific data on snags and down logs. After accounting for edge effects by buffering in 400 feet we assumed that most all the stands in our study area would meet the requirements for snags and down logs of PNW-447 definition. That matches well with the Forest ecology data base that says on the average we have 4 large snags per acre in natural stands. Meeting the down logs requirement has not generally been difficult in the interior of the stand, for our test area. Light areas upslope are more than compensated for by the riparian and toeslope areas in most cases.

III. Conduct evaluation of blocks to rate significance

We identified ecological diversity and social/recreation values as the primary objectives that would drive an assessment of old growth quality. Ecological diversity would include maintenance of compositional, functional, & structural components to support diverse habitat for both flora & fauna, and to maintain long term site productivity. Social values include aesthetic, recreational, cultural/historic, spiritual, existence, and option values. We have considered and tested a large number of potential criteria for evaluating these objectives. They include:

1. PNW Bulletin #447 old-growth criteria
2. Old growth development stage (early, middle, old)
3. Stand size
4. Stand shape
5. Percentage old growth in subdrainage/watershed
6. Topographic position (as affecting topographic stability & diversity)
7. Various tree uniqueness criteria (very tall, old, or large DBH)
8. Degree of human intrusion
9. Accessibility
10. Presence of T & E, or sensitive, species
11. Elevation
12. Stand condition (insects or diseases, windthrow, salvage history, etc.)
13. Diversity (mix of plant associations, unusual plant association, unique structure, etc.)
14. Biomass (as a reflection of site potential)

Evidence of human intrusion may be present but may not significantly alter the other characteristics and would be a subordinate factor in the description of a stand. The degree of human intrusion is highly subjective but since we buffered into the interior of the stand we were attempting to account for conditions in the interior of the stand. Evidence of human intrusion would include stumps, old skid roads, views of past timber harvests, etc.

Special Note

- * This process was put together from the perspective of evaluating the relative quality, benefits, and values of old growth, not as a tool to make all resource trade-offs.

IV. Landscape Management Strategy

1. Prepare map showing past harvest units, Forest Plan management areas, and stream system

- * Identify no harvest management areas, and mature forest within each allocation to obtain the base network of existing mature forest.

examples:

- Spotted owl habitat area
- Marten habitat area
- Special interest areas
- Special wildlife habitat areas
- Stream buffers
- Trail buffers
- other

2. Map stands rated as HIGH significance

- * Delineate areas of HIGH significance
- * Draw in corridors between no harvest areas and HIGH significance areas.
- * Draw in wider, more block-like corridors of forest between no harvest areas and areas of HIGH significance. This should be an expansion of the buffers.

3. Map stands rated as MEDIUM significance

- * Color in the MEDIUM significance areas.
- * Show corridors between MEDIUM significance areas and the HIGH significance and no harvest areas.

Criteria for evaluating connective corridors would include:

- the relative value of the stands being connected.
- the uses provided (a function of the width).
- the degree of topographic stability (based on width & topographic position).
- key linkages between broad scale units such as watersheds.

Note - In the analysis, we started with a minimum corridor width of about 800 feet which would compensate for edge effects and provide some interior habitat through the middle of the corridor. The expanded corridors took in entire blocks of timber stands to provide the connective corridors between blocks.

4. Map stands rated as LOW significance areas.

5. Project Level Application and Implementation

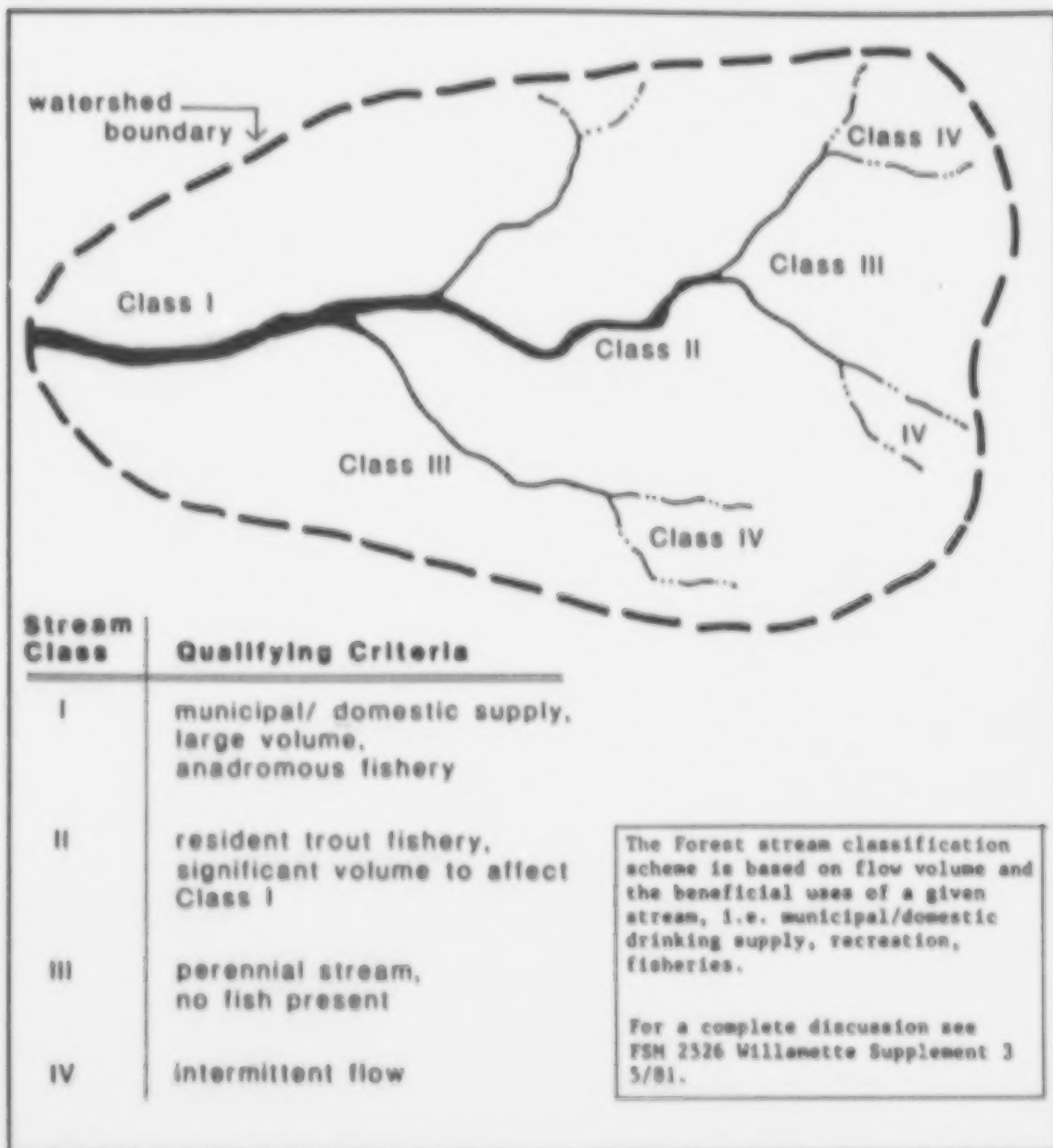
The determination of project level harvest acres would be done at this stage. Harvest should be concentrated in areas of the lowest significance. However, small lobes or fingers considered to be "insignificant" portions of otherwise "significant" stands may be included in harvest project. Similarly, unique areas found within otherwise less significant stands may be left because of their site-specific significance. This detailed stand level review would be an important step during reconnaissance at the project level and may need an evaluation process to screen those types of situations. In practice, stands of higher significance should not be negatively affected, and stands of lesser significance will generally be expected to be harvested.

An interpretation for prioritizing harvest areas.

	Priority
- Areas given a LOW significance level or use category	1
- Insignificant lobes/fingers of MEDIUM areas	2
- Areas connecting one or more MEDIUM significance areas	3
- MEDIUM significance areas	4
- Insignificant lobes/fingers of HIGH significance corridors or stands	5
- Widest portion of corridors connecting a HIGH significance area	6
- Minimum corridors connected to HIGH significance areas	7
- HIGH significance areas	8

APPENDIX 4. Standards and Guidelines for Management of Riparian Areas (Source: Willamette National Forest Plan 1990)

Figure III-5 Stream Hierarchy



MANAGEMENT AREA 15

Emphasis: Rivers, Streams, Wetlands, Lakes and Adjacent Riparian Areas

Management Goal

The primary goal in this management area is to maintain the role and function of rivers, streams, wetlands and lakes in the landscape ecology. A significant part of this goal is to manage the vegetation in the adjacent riparian areas for:

- Protection and rehabilitation of the aquatic and terrestrial riparian habitat;
- Maintenance and improvement of water quality while minimizing risks of downstream flooding;
- Management of riparian areas as corridors to provide dispersal habitat for plant and animal species by maintaining connectivity among mature and old growth stands of trees;
- Management and inventory of riparian areas for sensitive, threatened and endangered plant and animal species;
- Management of riparian areas for recreation and scenic use compatible with riparian dependent species;
- Monitoring the impacts of upland management activities on the health and function of the riparian ecosystem.

Desired Future Condition

This management area will provide a continuous and diverse habitat for riparian dependent species and high quality water by protecting and mapping wetlands and floodplains. The water bodies and associated riparian areas will contribute to the diversity and dispersion of fish, wildlife and plants within each subdrainage and also at the larger watershed level. This management area will also provide opportunities for public use and enjoyment through both dispersed and developed recreation management. The recreation uses will be managed to avoid or mitigate adverse effects on riparian dependent resources.

Stream channels will provide diverse, stable habitat for aquatic species as well as maintaining or enhancing water quality. Vegetation on adjacent lands will be managed to provide diverse stands of conifer and hardwood vegetation which provide habitat for riparian dependent species. The amount of large woody debris, both down and standing will be maintained at or above current levels. In areas where this material has been depleted as a result of past harvesting, the amount will increase either through rehabilitation projects, as a result of natural mortality of trees, or both. Along larger rivers and streams, optimal thermal cover for big game will be provided.

Description

This management area includes the bed, banks, and water column of rivers, streams, wetlands and lakes as well as the adjacent land areas. A riparian area is the adjacent land where vegetation and

microclimate are influenced by the stream or lake and the associated high water table. It includes the adjacent land which directly influences the shading and input of large and small organic material to the streams.

In addition, this area generally includes ponds, bogs, wet meadows and other areas identified in the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* and in the *Classification of Wetlands and Deepwater Habitats of the United States*.

Additional description of the resource values, objectives and operational considerations for this management area are found in the *Willamette National Forest Riparian Management Field Guide*.

Standards and Guidelines

RIPARIAN MANAGEMENT

- MA-15-01 The width of the riparian management area shall be identified by an on-site reconnaissance of topographic and biotic features and shall be based on the watershed objectives for fish and wildlife habitats, water quality, and recreation.
- MA-15-02 This management area shall include the 100-year floodplain within 400 feet from the edge of the active channel. Any portion of the 100-year floodplain extending beyond 400 feet should not be included in this management area, but shall be managed in accordance with Executive Order 11988.
- MA-15-03 Widths that should be considered when determining the management area boundaries are shown below. Exceptions to this range should be documented in project records or environmental assessments. Wider areas may be designated to allow protection of riparian stands from wind, to use logical topographic, biological or road boundaries. Narrower areas are anticipated only in exceptional situations.

Perennial Streams	Horizontal Width
Class I	150 to 400 feet
Class II	100 to 200 feet
Class III - Stable	50 to 100 feet
Class III - Potentially highly unstable & moderately stable	75 to 125 feet
Intermittent Streams	
Class IV - Moderately stable	25 to 50 feet
Class IV - Potentially highly unstable	25 to 100 feet
Lakes	600 feet
Reservoirs	NA
Small Wetlands	150 to 600 feet

MA-15-04 This management area does not include areas adjacent to reservoirs. Management of areas adjacent to reservoirs should follow direction of Forest-wide S&G for water quality and other resources and management area S&G as allocated.

MA-15-05 The following process shall be used when projects or management activities have the potential to create long term, short term, or cumulative adverse effects to the values of the rivers, streams, wetlands, lakes and adjacent riparian areas:

1. Locate the management area using the following criteria:

- Within the 100 year floodplain (less than 400 feet from active channel);
- Occupied by water tolerant vegetation;
- Having vegetation potentially capable of shading or contributing organic small matter to the water body;
- Having vegetation that contributes significantly to bank stability.
- Incorporate natural irregularities of topography and consider recreation and wildlife use patterns.
- Required to provide large woody material to the water body.

2. Identify the beneficial uses, values and objectives for the area. (See Appendix E, Watershed) Wetland and riparian area values and objectives should be established on a subdrainage area or larger, and should address connectivity of riparian habitat and the influence on downstream effects.

3. Identify the effects of proposed actions on the following:

- Public health, safety, and welfare, including water supply, quality, recharge, and discharge; pollution; flood and storm hazards; and sediment and erosion;
- Maintenance of the natural systems, including conservation and long term productivity of existing flora and fauna, species and habitat diversity and stability, hydrological utility, fish, wildlife, timber;
- Other uses of wetlands in the public interest, including recreational, scientific, and cultural uses. (See EO 11090)

4. Assess necessary actions to preserve the beneficial values, and to reduce or mitigate loss of wetlands by giving preferential consideration to riparian dependent resources when conflicts occur among land uses. (See FSM 2526.03)

5. Develop a riparian prescription that documents the objectives and actions to be implemented (including contract clauses and language as appropriate) in the riparian management area.

6. Monitor location and effects, and track results through appropriate databases.

Management practices shall be designed to prevent detrimental changes in water temperature or chemical composition, blockage of water courses, or

sedimentation within riparian areas which seriously and adversely affect water conditions or fish habitat. (36 CFR 219.27(e)).

WATER QUALITY

- MA-15-06** Vegetation will be managed to provide water temperatures which protect beneficial uses, as described in Oregon Administrative Rules 340-41-422.
- MA-15-07** All project proposals in the Salmon Creek and Marion Creek watersheds shall include an objective to improve water quality. A major part of this objective will be to maintain (Marion Creek) or reduce (Salmon Creek) maximum summer water temperatures that are 70 degrees F or less by 1995, and 67 degrees F by 2000. These watersheds are the water source for State of Oregon fish hatcheries.
- MA-15-08** At least 75% of the existing shade should be maintained.
- MA-15-09** Activities with potential effects on Class III and IV streams shall be scheduled and designed to maintain or improve water quality in downstream Class I and II waters.
- MA-15-10** Projects shall be designed using BMPs to meet Oregon State Water Quality Standards. Refer to *General Water Quality Best Management Practices, Pacific Northwest Region, 1988* and *Appendix E, Watershed* for further information on BMPs.
- MA-15-11** Streambanks and channel stability shall be protected, rehabilitated or enhanced to meet the water quality and aquatic habitat objectives.
- MA-15-12** Management in riparian areas shall provide for a continued input of large woody debris at rates similar to those in areas without past timber removal. Large wood will reduce the movement of debris torrents through channels and provide channel stability. Channel stability will also be maintained through measures listed in *Forest-wide Standards and Guidelines for Water Quality*.
- MA-15-13** The value and functioning of floodplains shall be protected, rehabilitated or enhanced. Floodplains are valuable for reducing stream velocity and temporarily storing water during high flow events.

WILDLIFE and FISH MANAGEMENT

- MA-15-14** Project activities within or adjacent to riparian areas shall protect, rehabilitate, or enhance streams to provide high quality habitat for a diversity of native aquatic species. Management indicator species for riparian areas are resident and anadromous salmonids.

Stable, diverse habitat for salmonids can be achieved with the following:

- Large wood: Diameter and length of woody pieces may vary according to the stream width and gradient; pieces larger than 25 inches in diameter are generally preferred. Large wood in the stream will provide a variety of habitat and nutrient characteristics.

- Pools: A primary pool every 5 to 7 channel widths in streams with less than a 2% gradient and every 3 to 5 channel widths in streams with a 2 to 8% gradient provides rearing habitat during summer low flows.
- Substrate: A well sorted variety of gravels, cobbles and boulders, with less than 20% of spawning gravels in fines (<1.0mm), and less than 25% embeddedness of cobbles in riffle areas provide salmonid and invertebrate spawning and rearing habitat.
- Floodplains: Stable, vegetated floodplains provide areas of slow water and refuge habitat during high flow events.
- Food source: Year-round input of leaf, needle, and insect material from a variety species provide a variety of food sources for salmonids and invertebrates.

- MA-15-15 Habitat rehabilitation or enhancement projects should be identified and evaluated in areas adversely affected by past events. Project proposals should consider long-term maintenance needs and should be monitored for effectiveness.
- MA-15-16 Habitat for riparian dependent terrestrial species shall be protected, rehabilitated, or enhanced. Factors to consider include microclimate, vegetation, and downed woody material.
- MA-15-17 Where designed to provide connectivity and dispersion, greater than 10 live, overstory trees per acre and 15 down trees per acre greater than 24 inches DBH should be maintained. This also provide down woody debris cover for small mammals, amphibians and reptiles.
- MA-15-18 Habitat potential for cavity excavator species should be at least 80% of the potential population habitat in riparian areas. (See *Forest-wide Wildlife Standards and Guidelines*).

RECREATION MANAGEMENT

- MA-15-19 Area management practices should result in a physical setting that meets or exceeds the ROS class of Roaded Natural.
- MA-15-20 Developed recreation and dispersed recreation sites should be compatible with riparian dependent resource objectives.
- MA-15-21 Projects to reduce safety hazards from dead, defective or hazardous trees in riparian areas should be evaluated to ensure adverse effects to riparian dependent resources are recognized and mitigated. This includes trees currently in river or stream channels and standing dead trees adjacent to trails or other recreation facilities.
- MA-15-22 Water withdrawn from streams or lakes for recreation facilities shall have no adverse effects on riparian dependent resources.

SCENIC RESOURCES

- MA-15-23 All design and implementation practices should be modified as necessary to meet the VQO of Partial Retention. In the event that unregulated harvest is necessary to salvage timber within the area, practices should be employed in a manner that seeks to achieve a VQO of Modification.

TIMBER MANAGEMENT

- MA-15-24 No programmed harvest shall be scheduled.
- MA-15-25 Salvage harvests should occur only when existing conditions are detrimental to riparian condition and riparian dependent resources. (See Forest-wide Standard and Guideline, Changed Environmental Conditions.)
- MA-15-26 A riparian prescription shall determine if trees need to be felled to maintain or enhance riparian objectives, if trees may be felled to facilitate activities in adjacent management areas, and if felled trees should be removed from the area. Riparian objectives are commonly met if yarding corridors through the area are spaced at least 200 feet apart.
- MA-15-27 Streambanks shall be protected by directional felling and suspending logs above streambanks adjacent to live water during yarding, and by using appropriate road design techniques where roads might impact streambanks. On streambanks adjacent to dry stream channels, logs will be fully suspended and directionally felled where practicable. Where it is not practicable, streambanks will be stabilized following yarding activities, and prior to stream flows in the channels.
- MA-15-28 Silvicultural prescriptions for existing regenerated stands within riparian areas shall be designed to achieve riparian objectives.
- MA-15-29 Silvicultural prescriptions should be developed for riparian areas affected by past harvest activities or catastrophic events to reestablish stands that provide a mixture of hardwood and conifer species similar to undisturbed sites.
- MA-15-30 Application of fertilizer to the riparian area, and to live water should occur only when prescribed to meet riparian terrestrial or aquatic objectives.

FIRE MANAGEMENT

- MA-15-31 Suppression strategies, practices and activities shall have minimal effects on objectives for water quality, aquatic and terrestrial wildlife and plant species, recreation, and visual resources.
- MA-15-32 Fuel treatment prescriptions should protect streamside vegetation and maintain the vegetation and woody debris necessary for channel stability.

MINERALS AND ENERGY

- MA-15-33 Mineral management shall be compatible with riparian resource management goals. Aquifers and downstream resources shall be protected as well as the immediate riparian resource.

LANDS

- MA-15-34 On lands considered for exchange a floodplain and wetland determination and assessment of impacts, with public notice shall be made. Acquisition of wetlands that may be of significant wildlife, fisheries or recreation values shall be encouraged.
- MA-15-35 Special use applications should show compatibility with management area objectives before approval.

FACILITIES

- MA-15-36 New roads should be planned to minimize effects on riparian areas. Projects should be evaluated as to which location will most likely meet riparian objectives. Locating roads outside of riparian areas is preferred when possible.
- MA-15-37 Where stream crossings are necessary for access, a crossing location should be selected which will best meet riparian objectives.
- MA-15-38 Construction and reconstruction of crossings or habitat improvements projects on fish bearing streams should allow for passage of both adult and juvenile fish during appropriate times of the year.
- MA-15-39 Deposits of sediment (silts and clays) in detrimental amounts shall be prevented during road construction and maintenance activities, and during periods of road closures. Road surface maintenance will use materials and methods designed to minimize sediment and deleterious chemicals.
- MA-15-40 Temporary roads constructed to facilitate rehabilitation and enhancement projects shall be compatible with riparian objectives, and should be closed following project completion.

RANGE MANAGEMENT

- MA-15-41 Domestic livestock grazing should not be permitted.

APPENDIX 5. Another View of New Forestry (Paper Delivered at Annual Meeting, Society of American Foresters, Eugene, Oregon, May 4, 1990 by William A. Atkinson, College of Forestry, Oregon State University, Corvallis, Oregon)

When you see the results of New Forestry in the field it is clear it is not new, it has been around for years - we have just called it a 'Real Estate Cut'. It is a pleasure to be here. There has not been a lot of discussion about New Forestry in the profession, at least not outside the narrow discipline of old growth ecology. You don't see anyone asking forest engineers, forest economists or practical operating people what they think about New Forestry. I have been wondering why this lack of debate and have come to the conclusion that nobody took these people seriously. New Forestry was dreamed up by academics working as a closed group on the HJ Andrews Forest. Most of us felt that nobody in their right mind would actually practice this stuff. But it turns out today that not only are people applying New Forestry across the landscape, but proponents of New Forestry have been successful in catching the ears of some very influential people. People such as the Chief of the Forest Service, supervisors of National Forests and regional foresters. The academics had a program when the Forest Service badly needed a program. So now we are all charging off to practice New Forestry. Have you been out in the woods recently to see the new cuttings on National Forest lands? You have to look pretty far anymore to find a good old fashioned clearcut. Most New Forestry harvest units look like the logger got half way through and walked away in disgust. This charging off and practicing something new in forestry is an example of what I call the 'lemming effect'. We all move in the same direction at once without a whole lot of thought and caught up in the spirit. A good example of the lemming effect is when we all grew container seedlings. Everybody had to have container greenhouses and produce container seedlings. It took years and years to finally sort that one out.

I would like to make five major points today (Figure 1). The first point is that New Forestry is obsolete, it fights the last war. The last war refers to the era of compromise in an attempt to manage the forest under multiple use. The second point is that the loss of land base for commercial forestry is the real issue; that's the new war. Third, the wood supply situation is too serious for what I call 'hobby silviculture' (my word for New Forestry). Fourth, New Forestry is not good forestry, technically it is a disaster; and point five, a better solution is to modify plantation forestry. If you were to remember nothing else of my talk, please remember these five points.

1. 'New Forestry' is Obsolete: It Fights the Last War
2. Loss of Land Base for Commercial Forestry is the Real Issue
3. The Wood Supply Situation Is Too Serious for 'Hobby Silviculture'
4. 'New Forestry' Is Not Good Forestry: Technically It's A Disaster
5. A Better Solution Is To Modify Plantation Forestry

Figure 1. Major Points

New Forestry is Obsolete: It Fights the Last War

Let's start with point one, New Forestry is obsolete, it fights the last war. Several years ago when New Forestry was first put forward we were still operating under a definition of multiple use that called for managing for several uses on the same piece of forest land. We have been arguing about the definition of multiple use for as long as I have been in forestry; does it mean managing one acre for many uses - or does it mean managing for one dominant use on an acre and separating the acres spatially?

Back in the days when we were still trying to manage the forest under the definition of several uses on one acre New Forestry might have made some sense, not much, but some. It took the politicians and the courts to finally settle the definition of multiple use. The definition today is to manage for a single dominant use, spatially separated. We have lands specifically set aside for riparian zones to protect stream banks and fish habitat, with no timber harvesting allowed. Areas have been set aside for headwall protection and protection of other unstable areas, with no timber harvesting allowed. Areas are set aside for various wildlife habitats and wildlife corridors, with very little timber harvesting allowed. Areas are set aside for research natural areas, for visual and scenic areas, for wild and scenic rivers, with no timber harvesting allowed. Areas are set aside specifically for parks and recreation areas, with no timber harvesting allowed. Areas are set aside for wilderness and for spotted owls, with no timber harvesting allowed. We have clearly defined multiple use to be single dominant use spatially separated.

So, under this scenario, we are no longer considering managing forest acres for several uses. This was the very reason that New Forestry was invented. When Jerry Franklin first proposed New Forestry he said it was a response to an either/or mentality; either lock it up or manage it intensively for timber (Figure 2). He also said that environmentalists must move away from preservation as the sole solution for their social objectives. The fact is that they haven't moved away from preservation, if anything they are pushing even harder. So this middle ground approach was aimed at fighting the last war, the war where we assumed that timber production would coexist with wildlife, scenery and all of the rest.



Figure 2. Original Concept of New Forestry

This war has been lost, New Forestry is no longer credible. The job now is to grow as much wood as we can on the scraps of forest that we have left. Now that we have locked up enough forest land to take care of fish, birds, animals, water, recreation and all of the other professed forest values lets get down to work and grow some wood that can actually be used by people!

Loss of Land Base for Commercial Forestry is the Real Issue

This brings me to point 2 - loss of land base for commercial forestry is the real issue. A major problem that we have in forestry today is the locking up of our timberlands, which results in the loss of commercial forest land base. Contributing to this loss of land base are the various resource specialists (fisheries and wildlife biologists, hydrologists, etc.) who are carving out their own set of land withdrawals. For example, the new Siuslaw National Forest Plan includes the withdrawal of 128,000 acres from the commercial land base. Removed are some of the most productive timber growing land on the Forest. Reasons given are to reduce landslides and protect fish populations, but there is very little scientific evidence to support these expectations. Figure 3 shows what is happening to available timberland on federal property in western Oregon. Forty percent of Forest Service land has been set aside for uses other than growing timber, as well as nineteen percent of Bureau of Land Management land. And this is before any withdrawals associated with the spotted owl being listed as threatened or endangered.

Western Oregon, May, 1990

	Available for Commercial Forestry (thousand acres)	Not Available	Percent Not Available
Forest Service	2,970	1,979	40
BLM	1,623	381	19
	4,593	2,360	34

Source: Timber for Oregon's Tomorrow: The 1989 Update. OSU 1990

Figure 3. Currently Available Federal Timberland

The Wood Supply Situation Is Too Serious for Hobby Silviculture

Point 3 is that the wood supply situation is too serious for hobby silviculture. I would like to remind the proponents of New Forestry that we are in deep sheepdip regarding wood supply in Oregon. Figure 4 shows western Oregon harvest levels for the Forest Service and BLM at 2.9 billion board feet over the years 1983-87. Latest plans show a slight reduction to 2.6 billion, but with the owl listed we are down to 1.6 billion board feet, a 55% reduction from the 83-87 average.

This is a shocking situation! We are looking at nothing less than a social calamity. Much of what forestry once offered toward building the rural economy of this State is rapidly vanishing. I would also like to point out in reference to this figure that the current plan numbers are suspect, even before the owl. The 2.6 billion board foot harvest level shown in the latest plans is in spite of the major land lockups discussed in point 2. In order to reach this level of cut the Forest Service is assuming intensive management for timber production on those lands that they have available to manage. Without intensive management the cut will decline even more. This reduction in wood supply is on top of what is lost because of the owl. We need to ask the Forest Service: "are you truly going to manage lands that you have available for timber production so as to achieve yields associated with intensive management"? If not, projected harvest levels are too high. For whatever its virtues, New Forestry will not produce anything like the timber that can be produced under plantation forestry.

FOREST SERVICE AND BLM

	Billion Bd. Ft.	% of 1983-87 Average
1983-87 Average	2.9	100
Latest Plans	2.6	90
Estimate With Owl Listed	1.6	55

Source: Timber for Oregon's Tomorrow: The 1989 Update. OSU 1990

Figure 4. Western Oregon Harvest Levels

Where are we going to produce wood for this world that we live in? We see a tremendous increase in world population and soaring demand for wood products. Where are we going to grow wood? Are we going to grow it here in the Northwest where we have the best species and the best land management practices, or are we going to grow needed wood in the tropics where soils end up washing down the streams and into the sea? What's best for planet Earth?

New Forestry Is Not Good Forestry: Technically It's a Disaster

I will start by listing some characteristics of New Forestry, since proponents deal with nebulous concepts, but not a lot of detail as to how you carry these practices out in the field. Somebody here today at least ought to list what we are talking about in terms of forest practices.

Here are some of the characteristics of New Forestry:

Lockups/No Cut

Wide buffers

All age silviculture

Partial cuts

Reduced clearcutting

Multiple entries for harvest (come back every 10 years and log it again)

Multi-layer stands

Retain overstory trees

Retain understory brush

Leave woody debris on site

Manage for a diversity of tree species

Leave wildlife snags and trees/leave entire stands for wildlife

Longer rotation ages

Landscape level considerations such as control over size and location of harvest units

Adjacency constraints (if you log this you can't log that)

Corridors for wildlife

Limitations on harvesting, particularly in watersheds, relating to water quality, water quantity and scenery.

Let's take a look at history and see what we can learn. Back in 1934, CJ Buck was Regional Forester for the Forest Service Region 6. He called for an abandonment of clearcutting to be replaced with frequent light cutting, which retained a large percentage of forest canopy and used single tree selection in all age stands. Does that sound familiar? This was the practice of the Forest Service up until the 1950's, and was tested on a large scale. Fortunately, one of the most famous silviculturists in the Northwest, Leo Isaac, decided that he would study the results of these practices. So Leo set up a series of permanent plots in Forest Service cutting units over a long period of time and published his results in 1956². Leo Isaac concluded that these practices resulted in accelerated windfall, huge mortality losses, damage to residual stands, and bark beetle attacks. Very little Douglas-fir regeneration was obtained, but there was regeneration of tolerant species such as cedar, hemlock, and fir. Another famous silviculturist addressed these cutting practices as well. David M. Smith, from Yale University, one of the best known silviculturists in the United States gave a paper at the Western Forestry Meeting in 1970 in which he called this experience 'a fiasco'³.

2 Isaac, Loe A. 'Place of partial cutting in old growth stands of the Douglas-fir region'; USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Research Paper No. 16, March 1956.

3 Smith, David M., 'Applied ecology and the new forests,' Proceedings: Western Forestry and Conservation Associations annual meeting, 1970.

I would like to read just a short quote from David Smith's paper. This section is called Ecological Lessons from the Selective Cutting Fiasco: "The selective cutting episode of 1930-50 has been too easily forgotten by foresters and overlooked by ecologists. Cuttings then conducted in the pursuit of single tree selection, development of all age stands, gentle treatment of nature and sustained yield proved to be such a fiasco in the ancient stands to which they were applied that our profession has been all too reticent to discuss them."

Another problem with New Forestry is its scientific basis and credibility. I speak for many scientists in this regard. Figure 5 depicts the scientific method for everything but New Forestry. Scientists usually start with some sort of a research hypothesis, go through a period of experimentation and trial, apply statistical tests, reach a conclusion, interpret what that means and set up small scale field trials, which are then applied operationally, evaluated, changed, and eventually, after quite a long process and iteration, arrive at dependable implementation. This is how we have developed the technology that lies behind plantation forestry. For example, look at the decades and decades of work that have gone into the development of reforestation practices. When I first started forestry, we were mostly planting dead seedlings. Today if we don't get 90% survival we think that something is wrong. It all didn't just happen, it took a tremendous amount of work by hundreds of people to put together this system of improved reforestation. The same thing is true of thinning and fertilization research. There have been literally hundreds of thousands of trees measured, treated and remeasured over decades of time to develop prescriptions for thinning and fertilization. We used to have big arguments on whether we should leave 360 or 340 Douglas-fir trees per acre after pre-commercial thinning. We put in trials, tests and hard work to determine which is the right number. And look at the amount of work that lies behind tree improvement programs. What we take for granted today as conventional forestry technology did not come easily or quickly.

Figure 6 depicts the scientific method that is being used by New Forestry proponents, an end run around the right way to establish new practices. They start with a research hypothesis, experiment, draw a conclusion and jump right into operational implementation on a large scale. And in between is a great deal of hype with scientists running around the halls of Congress, banging on doors in order to get their system in place. Completely lacking is the operational testing that is needed.

Consequences of New Forestry

Turn now to some of the consequences of New Forestry. I have divided my remarks into three areas: harvesting, future stand management, and protection/long term productivity.

Harvesting (Figure 7)

One of the first consequences of New Forestry is the increase in the cost of harvesting and silviculture due to the complex system being installed. We have demonstrated time and time again the tremendous costs involved in partial cutting and repeated logging entry. Silvicultural costs have not been studied as much, but we know that it is going to take a great amount of money and talent to 'pull off' these New Forestry systems. Where is the Forest Service going to get the money and where is the Forest Service going to get the talent? It seems to me that New Forestry is a device to move deficit timber sales to Western Oregon. Where is the additional money going to come from to practice New Forestry? It is going to come right off stumpage receipts. Counties are not going to get as much money as they should for schools and roads, and the Federal Treasury is not going to get as much. Recipients of timber receipts do not even know that they are being shorted; it's a hidden cost. Where is the Bureau of the Budget when we really need it?

For Everything But 'New Forestry'

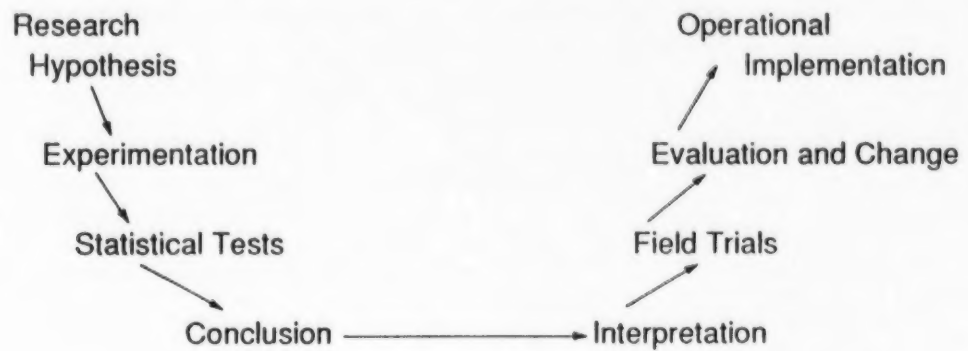


Figure 5. The Scientific Method

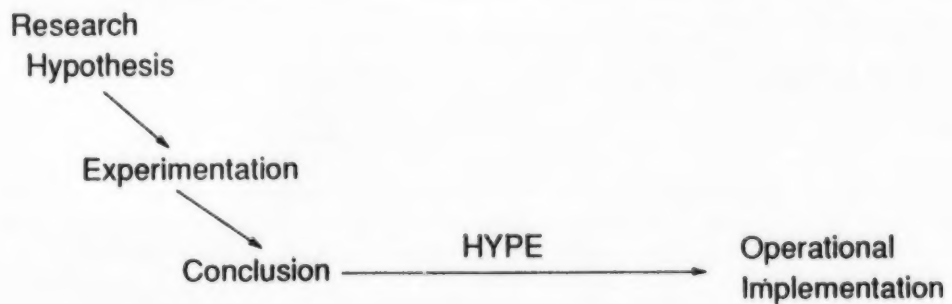


Figure 6. The Scientific Method for New Forestry

Harvesting

- Increased costs due to complicated logging and complex silviculture
- Loss of revenue and decreased yields due to:
 - leaving merchantable material in the woods
 - windfall from trees unaccustomed to open conditions
 - unmanaged stands left as buffers or for wildlife
- Damage to residual trees during harvesting and site preparation
- Safety in logging, as workers try to avoid standing snags and trees

Figure 7. Consequences of New Forestry - I

Future Stand Management

- Decreased Yields: Sloppy clearcuts make sloppy plantations
- Lack of full stocking, especially of intolerant Douglas-fir and pines
- Destruction of advanced regeneration during future harvest entries
- Disease passed from remaining overstory to understory (eg. mistletoe)
- Brush buildup as understory vegetation is exposed to light: Intense brush competition with conifers

Figure 8. Consequences of New Forestry - II

The second point under harvesting (Figure 7) is the loss of revenue and decreased yields due to leaving merchantable material in the woods, increased windfall and unmanaged stands left as buffers or for wildlife. Much of the material that is being left after logging under New Forestry is merchantable. It is not cull as they would have you think, it is valuable material. This is an investment of capital being left out in the forest.

Windfall is a major problem. We have a good example of that close to Corvallis. I am Director of OSU's Research Forest. Last year I was persuaded to try some of these New Forestry cuts and we have a windfall disaster on our hands today, over 3 million board feet blown down on a forest of only 12,000 acres. Much of this is associated with partial cuts. I'm waiting now for an old-growth ecologist to come into my office to tell us to leave it out there for organic addition to the soil. Anyone who manages timber on the coast of Oregon or in the Cascades has got to deal with wind as a major management factor, as much in the picture as site quality or soil characteristics. You have to design systems that work, and one thing we have learned is not to leave trees standing by themselves when they have been growing in a closed stand - they blow down. The storm that came in in January 1990 is not a unique storm. We have these storms every few years. We have got to manage around windstorms. I would like to know what the windfall situation is on the HJ Andrews Forest and on the local national forests. How much timber was blown down and how much of it is associated with these New Forestry types of harvest? How much of this wood will not be utilized?

The third point on Figure 7 is damage to residual trees from logging and site preparation. How do you protect scattered trees when you leave them standing in the middle of a logging unit? It can be done but it is costly. How do you protect trees during site preparation? If you want to burn, how do you burn without killing the trees that you left? I have had silviculturists tell me that the wildlife biologist says it is okay to kill these trees: "we don't mind losing some of them because they will turn into snags, which we want." That's fine, but capital is being invested out there for wildlife and everybody needs to be aware of that.

The final point on Figure 7 is safety. People are getting killed by snags and trees left in the middle of logging areas. State of Washington safety people are really clamping down on partial cuts because of the danger of working around snags and trees.

Future Stand Management (Figure 8)

Turn now to future stand management and some of the consequences of New Forestry. The first point is decreased yields: sloppy clearcuts make sloppy plantations. You don't hear proponents of New Forestry talk very much about wood productivity. They don't really seem to care very much about forest yields. When you go out in the woods and see the results of New Forestry in practice the thing that will hit you is that you do not have anything like the full stocking easily obtainable under plantation silviculture. When you go on a field trip and look at New Forestry be sure and get into the unit; look at stocking; and look at the amount of brush, weeds and trees being left to compete with whatever seedlings are there. People who propose New Forestry don't often show you the stand close up, they like to stand on a landing and wave their hands over an entire watershed. Don't let them do that, make them take you out in the field and show you what is really going on. That is point 2 of Figure 8, lack of full stocking, especially of intolerant Douglas-fir, as Leo Isaac pointed out so well.

Point 3 of Figure 8 concerns destruction of advanced regeneration during future harvesting. It is always a problem to remove overstory trees without destroying advanced reproduction. If you are not going to remove the overstory but leave it for the next rotation, that needs to be considered as a capital investment and accounted for into the cost benefit analysis.

Point 4 (Figure 8) is the disease situation you are setting up. New Forestry may well be a strategy for disease enhancement. A good example is mistletoe. Disease may be the 'revered old-growth heritage' that is passed down from old stands to young stands.

The final point of Figure 8 deals with brush buildup as understory vegetation is exposed to light. New Forestry could well be encouraging intense brush competition with conifers. Anybody who has worked with a vigorous brush species knows what happens when you take off the overstory and allow light to reach the forest floor. The brush goes absolutely 'bananas'; it is going to crowd any conifers that are left. Proponents of New Forestry have got to address these problems somehow. You don't hear them worrying about practical problems, they are much more concerned with nebulous ecological concepts and political adroitness than they are with trying to come up with solutions that work.

Soil Protection/Long Term Productivity (Figure 9)

The final point dealing with consequences of New Forestry is soil protection and long term productivity. One concern is the soil compaction that you get with multiple entry logging. It is hard enough to control a logging operation the first time, but to try and control it time and time and time again is just leading to trouble. In my opinion we ought to go in and do our logging once and then stay out for the rotation. Point 2 of Figure 9 concerns the disastrous wildfire potential from slash. If we are going to leave great quantities of slash out there it is going to dry out and could be a disaster waiting to happen. Finally, New forestry brings us the happy prospect of insect buildup in slash (e.g. bark beetles) which then move into green trees. This is another observation of Leo Isaac. We have to deal with fire and insects if we leave a lot of slash out there in the woods.

And finally, visual appearance. To me New Forestry looks like a mess. I doubt whether the public will feel it is much of an improvement on clearcuts.

A Better Solution Is to Modify Plantation Forestry

My final point is that a better solution is to modify plantation forestry. I have been involved with plantation forestry most of my career and am very proud of it. You know, we have been logging in the Northwest for about 150 years, every year for 150 years. We have today the most beautiful young forests in the world. Healthy, vigorous, fast growing forests. Our third rotation is outgrowing our second rotation and our second rotation did better than the natural forest. We are proud of the work that we have been able to accomplish in developing techniques for plantation forestry. Believe me, if we hadn't been practicing plantation forestry for the last 30 years we would be in even worse trouble than we are with regard to wood supply. These young forests that are coming on line are going to save our industry, millions of acres of beautiful young plantations. So I would ask: "do we throw out a proven silvicultural system or do we modify it to achieve new goals?" I believe that a better solution to this problem is considerably closer to plantation forestry than it is to New Forestry (Figure 10).

Here are some practical ways to modify plantation forestry to meet new goals, briefly discussed under the categories: harvesting, roads and site preparation; stand management; and protection/long term productivity.

Under harvesting, roads and site preparation, I think we ought to use clearcuts except in areas that are visually sensitive; we ought to construct narrow roads carefully located and carefully constructed so that they stay on the hill and don't slip out. We should use minimum impact logging: cable systems, helicopter systems, carefully controlled ground skidding. If we do compact skidtrails they ought to be ripped so they can be brought back into production. We ought to do minimal site preparation, light burning in the spring, or use harvesting to control

Protection/Long Term Productivity

- Soil compaction with multiple entry logging
- Disastrous wildfire potential from slash
- Insect buildup in slash; then move to green trees
- Visual Appearance: New Forestry looks like a mess; no improvement on clearcuts

Figure 9. Consequences of New Forestry - III

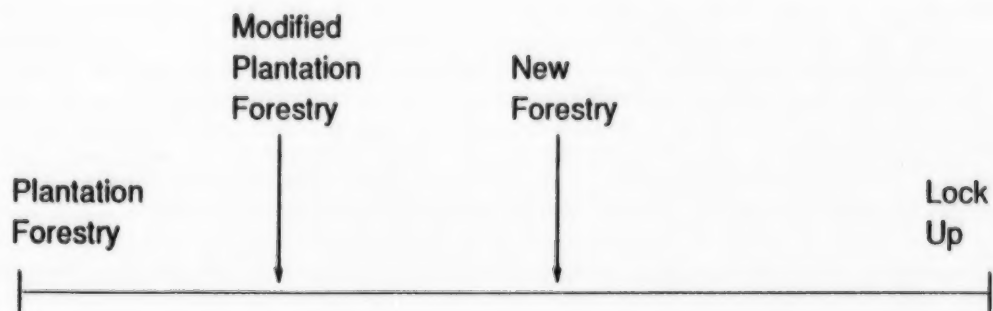


Figure 10. A Better Solution

slash. We should be doing shovel piling or minimal scarification, trying to live with more slash and more brush (not as much as New Forestry people will advocate, but they are on the right track here, we need to leave more organic matter out in the woods). We should clump wildlife trees around the edges of cutting units and in places where they are out of the way.

Stand management techniques should result in something very close to full stocking, using the best quality genetically improved planting stock. We ought to be planting through more slash, mixing our species, using micro sites cleverly, and even putting some hardwoods in. When it comes to controlling competing vegetation, we need to control the worst of it using chemicals (and by hand if we must). We should appreciate the diversity that other species add to the forest, especially when conifers are away and free to grow; then we can allow other plants to grow between them. We ought to maintain species diversity throughout thinning. We ought to be leaving special areas for wildlife, but be clever about it; leave areas that are hard to log, sensitive soils, wetlands, rocky areas, low sites, hardwood patches, meadows or buffers.

Finally, under protection and long term productivity, we should control the amount of slash we want on the forest by whole-tree yarding and the location of delimbing. Do we leave limbs and tops on the landings or in the woods? It is important to be managing soils by adding organic matter, by allowing alder to grow intermixed, and by fertilizing.

I will close with some advice to advocates of New Forestry. Don't move too rapidly, use caution, consider cost and yield implications of what you are suggesting. Study research findings, understand biological and engineering principles, learn from history, study past results. Don't make it too complicated, involve experienced operational people and keep logistics and people resources in mind when you are designing your systems. And finally, borrow the best ideas from plantation forestry.

Thank you.